HEWLETT-PACKARD COMPANY / OPERATING AND SERVICE MANUAL

403B
403B-DB
TRANSISTORIZED AC VOLTMETER

hp 403B

CERTIFICATION

THE HEWLETT-PACKARD COMPANY CERTIFIES THAT THIS INSTRUMENT WAS THOROUGHLY TESTED AND INSPECTED AND FOUND TO MEET ITS PUBLISHED SPECIFICATIONS WHEN IT WAS SHIPPED FROM THE FACTORY.

hp FURTHER CERTIFIES THAT ITS CALIBRATION MEASUREMENTS ARE TRACEABLE TO THE NATIONAL BUREAU OF STANDARDS TO THE EXTENT ALLOWED BY THE BUREAU'S CALIBRATION FACILITY.

OPERATING AND SERVICE MANUAL

MODEL 403B/403B-db

SERIALS PREFIXED: 225

TRANSISTORIZED AC VOLTMETER

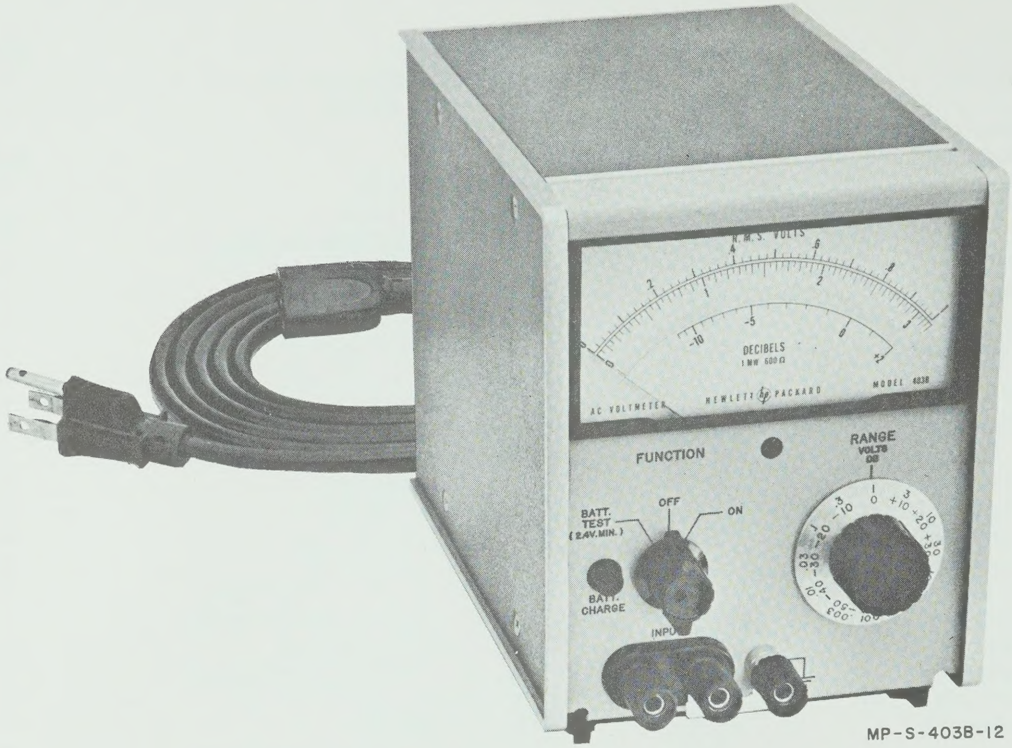
01325-2

Printed: APRIL 1964

TABLE OF CONTENTS

LIST OF TABLES

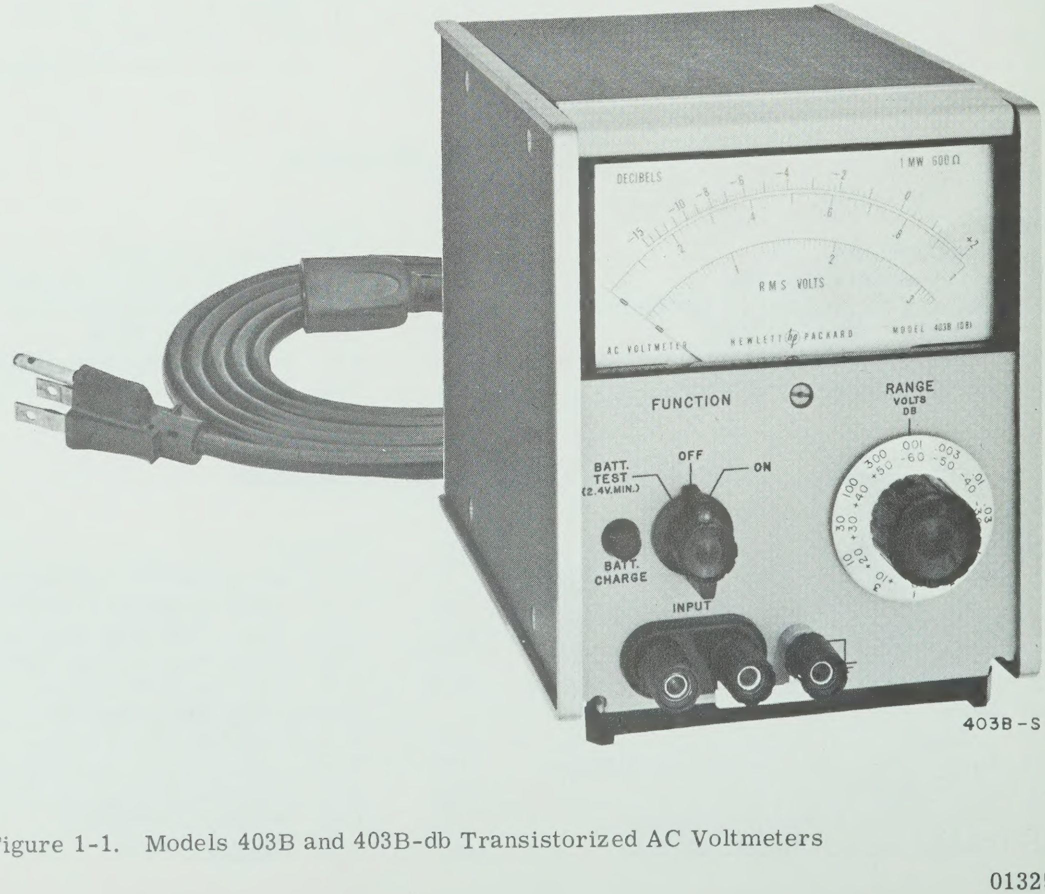
LIST OF ILLUSTRATIONS



MP-S-403B-12

The hp Model 403B Transistorized AC Voltmeter

The hp Model 403B-db Transistorized AC Voltmeter



403B-S-4A

Figure 1-1. Models 403B and 403B-db Transistorized AC Voltmeters

SECTION I
GENERAL INFORMATION

1-1. DESCRIPTION.

1-2. The ⓗⓟ Models 403B and 403B-db Transistorized AC Voltmeter are general purpose instruments that measure rms values of AC voltages in the 5 cps to 2 mc range. Both instruments have full-scale ranges from 1 mv to 300 volts (-72 dbm to +52 dbm) in a 1, 3, 10 sequence. The Model 403B meter face is calibrated with the upper scale in volts (rms); the Model 403B-db meter face is calibrated with the upper scale in db. The Models 403B and 403B-db are shown in figure 1-1, and specifications are given in table 1-1.

1-3. The Models 403B and 403B-db operate from Nickel Cadmium batteries. The instruments also include a self-contained battery charger which operates on 115 or 230 volts AC.

1-4. This manual discusses the Model 403B and 403B-db in terms of the Model 403B. The Model 403B-db will be mentioned only when it differs from the Model 403B.

Table 1-1. Specifications

RANGE:
0.0001 to 300 volts rms full scale (12 ranges) in a 1, 3, 10 sequence.

FREQUENCY RANGE:
5 cps to 2 mc.

ACCURACY:
% of Full Scale.

MODEL 403B ACCURACY SPECIFICATION

Frequency	0 to 50°C	0 to -20°C
10 cps to 1 mc	±2%	±8%
5 to 10 cps and 1 to 2 mc*	±5%	±8%

MODEL 403B-db ACCURACY SPECIFICATION

Frequency	0 to 50°C	0 to -20°C
10 cps to 1 mc	±0.2 db	±0.7 db
5 to 10 cps and 1 to 2 mc*	±0.4 db	±0.7 db

* ±10% (±0.8 db) on 300 v range. Use ⓗⓟ 10001A 10:1 Divider and ⓗⓟ 10111A Adapter to retain ±5% (±0.4 db) accuracy while measuring up to 425 v rms at 1 to 2 mc.

METER:
Individually calibrated, taut band. Responds to average value of input waveform and is calibrated in the rms value of a sine wave.

NOMINAL INPUT IMPEDANCE:
2 megohms; shunted by approximately 50 pf on 0.001-volt to 0.03-volt ranges, 25 pf on 0.1-volt to 300-volt ranges.

OVERLOAD PROTECTION:
Fuse protected.

DC ISOLATION:
Signal ground may be ±500 vdc from external chassis.

POWER SUPPLY:
4 rechargeable batteries (furnished). 40-hour operation per recharge (20 hours at -20°C), up to 500 recharging cycles (expected battery life of 20,000 hours). Recharging circuit is self-contained and functions automatically when instrument is operated from ac line (115 or 230 v ±10%, 50 to 1000 cps, approx. 3 watts).

TEMPERATURE RANGE:
-20°C to +50°C.

DIMENSIONS:
5-1/8 in. wide, 6-3/32 in. high, 8 in. deep.

WEIGHT:
Net 6-1/2 lbs., shipping 10 lbs.

ACCESSORIES AVAILABLE:
ⓗⓟ 11002A Test Leads, 5ft. long, dual banana plug to alligator clips. ⓗⓟ 11003A Test Leads, 5 ft. long, dual banana plug to probe and alligator clip. ⓗⓟ 10001A 10:1 Divider and ⓗⓟ 10111A, Adapter.

ACCESSORY FURNISHED:
Detachable power cord.

1-5. DIFFERENCES BETWEEN INSTRUMENTS.

1-6. The Model 403B carries a five-digit serial number with a three-digit prefix (000-00000). The prefix changes only when a change is made in the instrument. The prefix, then, is an identifier, and it appears on the title page of this manual to indicate to which instrument this manual directly applies. A supplement may be included with this manual to indicate the necessary changes to be made in the manual to make the manual apply directly to Model 403B which carries a different serial number prefix.

1-7. ACCESSORIES AVAILABLE.

1-8. To increase the usefulness of your instrument, the following accessories are available:

a. ⓗⓟ Model 11005A Line Bridging Transformer.

b. ⓗⓟ Model 11039A Capacitive Voltage Divider.

c. ⓗⓟ Model 10111A BNC-To-Binding Post Adapter.

d. ⓗⓟ Model 10001A 10:1 Divider Probe.

1-9. Table 1-2 provides information and use of the accessories mentioned above as well as other useful accessories.

Table 1-2. Accessories Available

Model No.	Use	Features
11002A 11003A	Test Leads	Dual Banana Plug to Alligator Clips Dual Banana Plug to Probe and Alligator Clip
10001A	10:1 Divider	10 Megohms probe
10111A	Adapter	Binding post to BNC
11005A	Line Bridging Transformer Provides balanced 600-ohm input to unbalanced 600-ohm output for measurements on balanced lines.	Terminating Resistance: 600 or 10K ohms Frequency Range: 20 cps to 45 kc Power Handling Capacity: +15 dbm (4.5v into 600Ω)
11039A	Capacitive Voltage Divider (Division ratio: 1000:1)	Accuracy: ±3% Input Capacity: 15 pf ±1 pf Max. Voltage Rating: 60 cps 25 kv, 100 kc 22kv, 1 mc 20 kv, 10 mc 15 kv, 20 mc 7 kv.
11029A 11030A 11031A 11032A 11033A 11034A	Shunt Resistors For adapting the 403B to current measurements (1 μa to 3 amps full scale, 1 watt maximum).	Resistance / Max. Current / Accuracy: 0.1 ohm / 3 amps / 470A only: 1 ohm / 1 amp / ±1% to 100 kc 10 ohms / 300 ma / ±5% to 1 mc 100 ohms / 100 ma / all others: 600 ohms / 41 ma / ±1% to 100 kc 1000 ohms / 30 ma / ±5% to 4 mc
456A	AC Current Probe 1 mv/ma ±1% at 1 kc	negligible / 1 amp rms, 1.5 amp peak / ±2%, 100 cps to 3 mc

SECTION II
INSTALLATION

2-1. INSPECTION.

2-2. Unpack the instrument upon receipt and inspect it for signs of physical damage such as scratched panel knobs, etc. If there is any apparent damage, file a claim with the carrier and refer to the warranty page on the back of this manual.

2-3. An electrical inspection should be performed as soon as possible after receipt. To aid in electrical inspection, performance checks are included in section V, paragraph 5-37.

2-4. POWER REQUIREMENTS.

2-5. The AC power circuit which provides charging current to the Nickel - Cadmium batteries in the instrument can be connected to a 115- or 230-volt, 50-60 cps, source. A switch located on the rear panel of the instrument allows the user to select 115- or 230-volt modes of operation.

2-6. INSTALLATION.

2-7. The ⓗⓟ Model 403B is fully transistorized; therefore no special cooling is required. However, the instrument should not be operated where the ambient temperature exceeds 55°C (140°F).

2-8. REPACKAGING FOR SHIPMENT.

2-9. The Model 403B is shipped in a foam-pack and cardboard carton (see figure 2-5). When repackaging the instrument for shipment, the original foam-pack and cardboard carton can be used if available. If not available, they can be purchased from Hewlett-Packard Co. (refer to section VI, misc.). Use the following as a general guide for repackaging the instrument.

a. Place the instrument in the foam-pack as shown in figure 2-1.
b. Mark the packing box with "Fragile," "Delicate Instrument," etc. as appropriate.

NOTE

If the instrument is to be shipped to Hewlett-Packard for service or repair, attach to the instrument a tag identifying the owner and indicating the service or repair to be accomplished; include the model number, and full serial number, of the instrument. In any correspondence, identify the instrument by model number, serial number and serial number prefix.

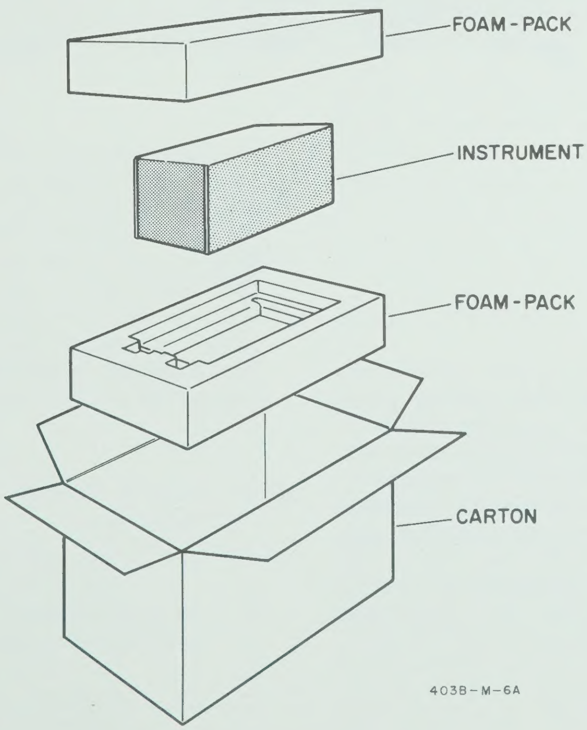
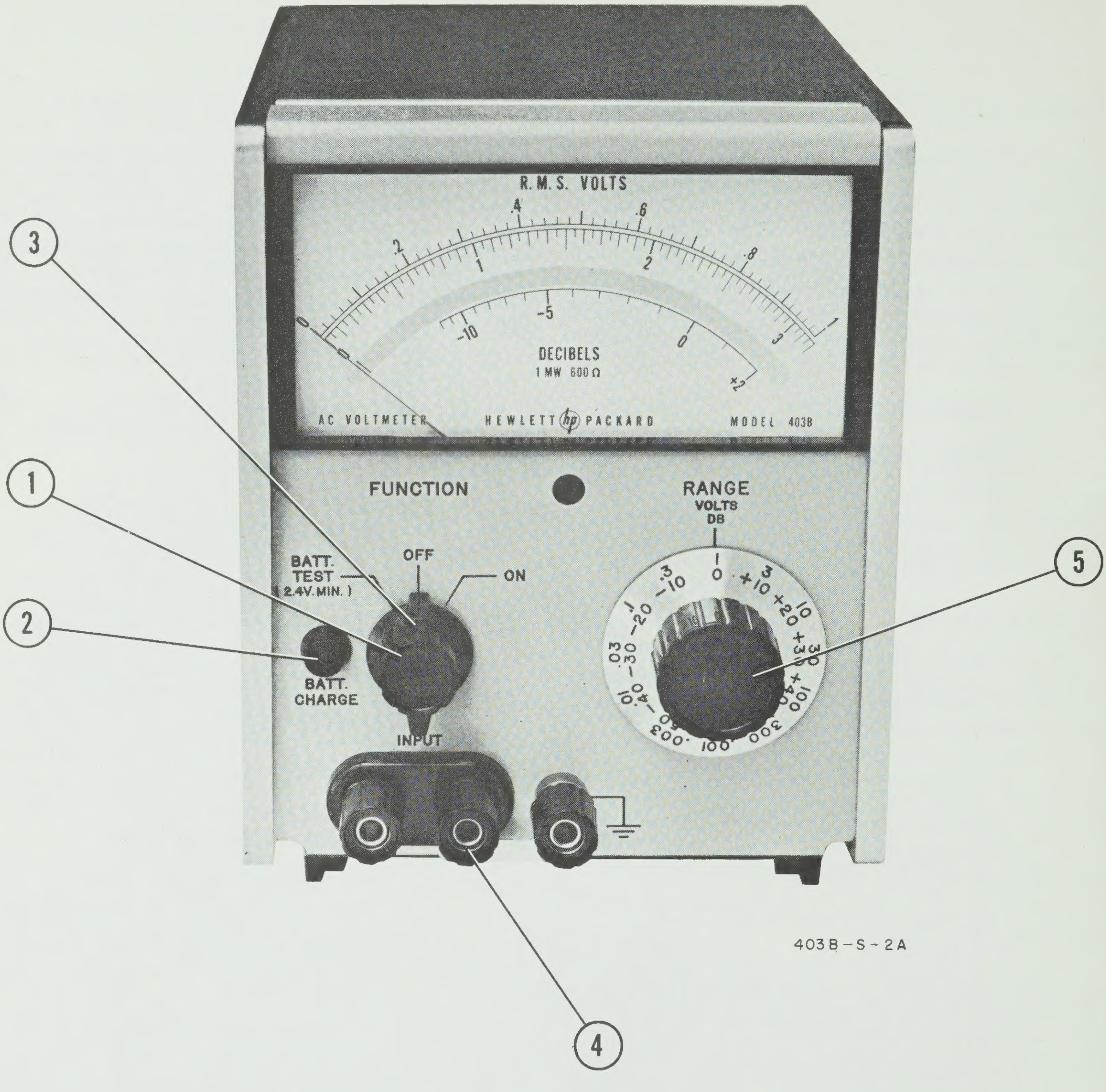


Figure 2-1. Repackaging for Shipment



1. FUNCTION: Three-position switch checks battery charge when the switch is in the ON position; it applies 27.5 volts from the Nickel-Cadmium batteries to the Model 403B circuitry. When in the BATT. TEST position, the meter should read above 2.4 volts on the "0-3" meter scale, which is equivalent to 24 vdc at the battery.

2. BATT. CHARGE: Glows when instrument is connected to an AC source with the FUNCTION switch turned to the ON position.

3. Fluorescent Indicator: Glows when instrument is on.

4. INPUT: Connect voltage to be measured to these terminals.

5. RANGE: Selects range from 0.001 volt to 300 volts rms full scale in a 1, 3, 10 sequence.

Figure 3-1. Front Panel Description

SECTION III
OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. This voltmeter is ready for use upon receipt from the factory and will give specified performance after a short warm-up period. Allow approximately 60 seconds warm-up for optimum performance.

3-3. FRONT PANEL DESCRIPTION.

3-4. A description of front panel controls is given in figure 3-1. The descriptions are keyed to the photo that accompanies the figure.

3-5. OPERATING PROCEDURE.

3-6. The operating procedure for the Model 403B is given in figure 3-2. Instructions are keyed to the photo that accompanies the figure.

3-7. BATTERY CHARGING INFORMATION.

3-8. The 403B has a self-contained battery charger. This instrument is continually charging the batteries whenever the FUNCTION switch is ON and the line cord connected to a 115- or 230-volt source. In the event of complete discharge, the 403B can be used after twenty minutes of recharging with the line cord connected to an AC source. Complete recharge requires approximately 60 hours (depending on setting of R39) when the Nickel Cadmium cells are completely discharged. (Refer to Section IV, Paragraph 4-25.)

CAUTION

The four Nickel Cadmium batteries in the ⓗⓟ 403B are in hermetically - sealed containers. Under high temperatures (above $50^{\circ}C$), hydrogen in the hermetically-sealed battery container can build up to large pressure, causing damage to the batteries and/or instrument. (Refer to Section IV, Page 4-3.)

3-9. INSTRUMENT TEMPERATURE LIMITS.

3-10. This instrument has certain temperature limitations. The design of this instrument has provided for safe and stable operation over the range of -20 to $+50^{\circ}C$ (-4 to $+122^{\circ}F$). This temperature range is quite adequate for most users; however, keep these limits in mind when operating under field conditions. Internal temperatures in excess of $122^{\circ}F$ are quite easy to obtain if the instrument is left in the sun, even if the air temperature is quite moderate. A good practice is to be certain that the instrument is not stored or operated in direct sunlight to avoid the possibility of reduced performance. When using 403B at temperatures below $0^{\circ}C$, be certain the batteries are fully charged prior to subjecting instrument to this temperature.

CAUTION

Nickel - Cadmium cells in this instrument are hermetically sealed. Damage to cells may occur if exposed to extremely high temperatures (above $50^{\circ}C$).

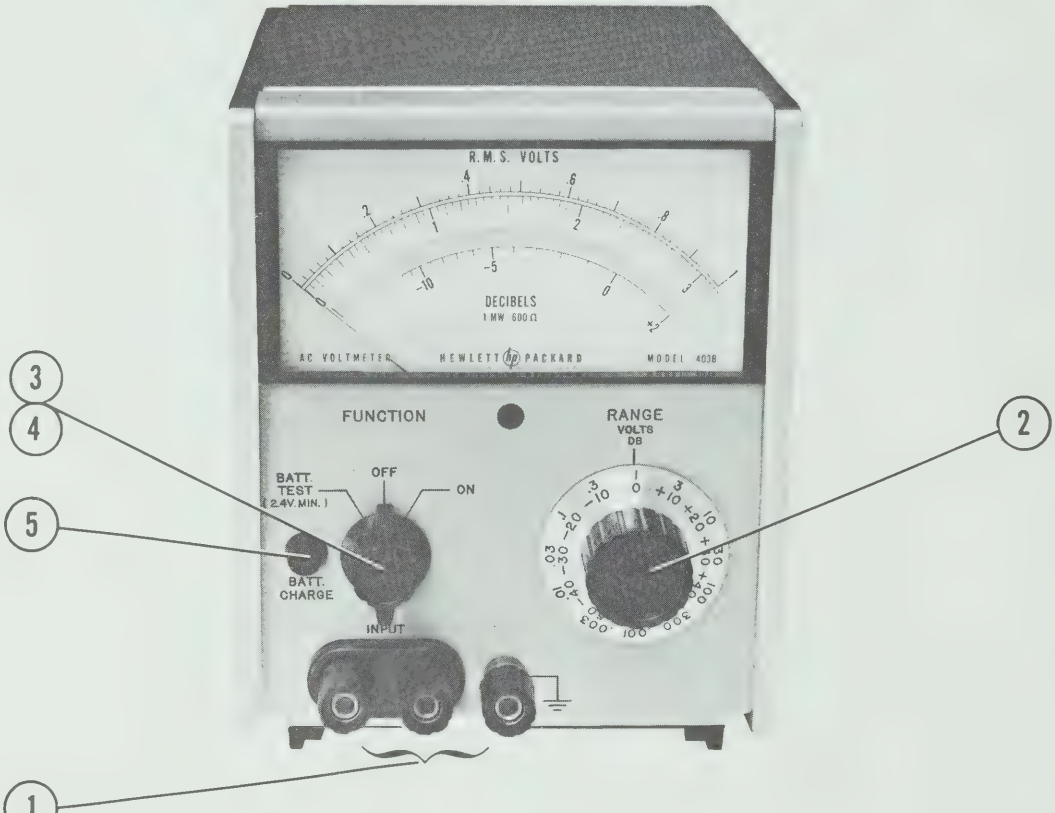
3-11. INPUT PROTECTION FUSE.

3-12. A 1/16 ma fuse is included in series with the input circuit which will open with repeated or excessive overload. This fuse is accessible when the cabinet is removed. A spare fuse is included inside the instrument.

3-13. VOLTAGE MEASUREMENTS.

3-14. Always leave the instrument on the 1-volt range or higher when making initial connections to circuits which have dc levels over 25 volts. Then switch to the appropriate lower range to obtain an up-scale reading. This practice should be used when making power supply ripple measurements where the dc voltage may be as much as 600 volts, but the ac ripple is only a few millivolts.

3-15. If measurements are made from a high-impedance source, hum pick-up can affect the meter indication because of high impedance of both the source and voltmeter. Shielded leads will reduce pick-up although they will cause an increase in the capacity shunted across the source, with the possibility of excessive circuit loading.



1. Connect voltage to be measured at the INPUT terminals (red terminal positive and ungrounded black terminal negative).

NOTE

The outer black ground terminal is connected to chassis ground. For voltage measurements at chassis ground, connect the ungrounded black terminal to the grounded black terminal.

2. Select range which gives a reading in the upper 2/3 of the meter scale (This will insure the highest degree of accuracy.).

3. Set FUNCTION switch to BATT. TEST; front panel meter reading should be greater than 2.4 volts (corresponds to 24 volts at battery). If less than 2.4 volts, the battery needs recharging. Refer to Paragraph 3-7 for battery charging instructions.

4. Set FUNCTION switch to ON; lamp function knob will glow, and the instrument is ready for voltage measurement.

5. When the instrument is connected to an AC power source and the FUNCTION switch is to ON, the BATT. CHARGE lamp will glow, indicating that the battery is being charged.

Figure 3-2. Voltage Measurements

3-16. The rated 2 megohms input resistance will be effectively reduced (above 1 kc) by shunt input capacity. (This fact is true for any ac voltmeter.) 50 pf has a reactance of 0.8 megohm at 4 kc, 80,000 ohms at 40 kc, etc. The shunt capacity decreases on the higher ranges (see table 1-1). This factor should be considered when measuring higher frequency voltages in circuits of moderate impedance level.

3-17. Severe RF circulating currents are generated at potentials approaching 300 volts in the 1 to 2 mc frequency range. These severe ground currents limit the accuracy of the 403B to ±10% on the 300-volt range. By using ⓗⓟ accessories 10001A (10:1 divider) and a 10111A (adapter) shunted by a 2-megohm resistor, the accuracy of the 403B can be retained to ±5%.

3-18. WAVEFORM ERRORS.

3-19. In order to maintain accuracy of measurement, one must remember that this instrument is an average responding device, but the meter scale is calibrated in terms of the rms value of a pure sine wave. If the waveform of the voltage being measured contains appreciable harmonics or other spurious voltages, the meter indication will deviate from the true rms value on the order indicated by table 3-1.

Table 3-1. Effect of Harmonics on Model 403B Voltage Measurements

Input Voltage Characteristics	True RMS Value	Value Indicated by 403B
Fundamental = 100	100	100
Fundamental +10% 2nd harmonic	100.5	100
Fundamental +20% 2nd harmonic	102	100 - 102
Fundamental +50% 2nd harmonic	112	100 - 110
Fundamental +10% 3rd harmonic	100.5	96 - 104
Fundamental +20% 3rd harmonic	102	94 - 108
Fundamental +50% 3rd harmonic	112	90 - 116

3-20. This table is a general one and applies to any average responding rms calibrated voltmeter. As can be seen in the table, errors are small even with a badly distorted signal (i.e.; 20% 2nd harmonic gives +0, -2% error).

3-21. DECIBEL MEASUREMENTS.

3-22. Measurements in terms of decibels are made in the same way as voltage measurements except that the indication is read on the db scale (-12 to +2 db). The decibel level is the algebraic sum of the meter db scale indication and DB VOLTS (RANGE) position.

3-23. To read power directly in dbm, (0 dbm=1 milliwatt into 600 ohms) the measurement must be made across 600 ohms. Comparative db measurements (without respect to reference level) may be obtained by direct reading provided each measurement is made across the same impedance value. The difference in decibels between two or more measurements may be obtained by reading directly from the db-scale indications. (For examples of db measurements, refer to table 3-2.)

Table 3-2. Examples of Voltage and DB Measurements

Range Switch	Meter Scale	Meter Indicates	Actual Level
Voltage measurements:			
300	3	1.8	180
10	1	0.44	4.4
.003	3	2.3	.0023
.001	1	.27	.00027
DB measurements:			
+40 db	db	+2 db	+42 db
+40 db	db	-7 db	+33 db
+10 db	db	-6 db	+ 4 db
-30 db	db	0 db	-30 db
-30 db	db	-8 db	-38 db
*-50 db	db	-9 db	-59 db
-60 db	db	+1 db	-59 db

*NOTE: In cases where a meter scale reading below -8 db is obtained, it is best to switch to the next lower range on the instrument so a reading will be obtained in the upper portion of the scale where highest accuracy may be obtained.

The same situation exists for voltage measurements. When a reading is obtained in the lower 1/3 scale, the range switch should be switched to the next lower range to obtain a reading in the upper 2/3 scale.

3-24. IMPEDANCE CORRECTION GRAPH.

3-25. To obtain the level in dbm with respect to impedances other than 600 ohms, the meter correction graph shown in figure 3-3 may be used. The level in dbm will be the algebraic sum of the level as indicated on the meter and the correction shown on the graph. For example, if the range switch is at the +30 db position, the measurement made across 90 ohms, and the indication on the DB scale +1, the level in dbm is obtained as follows:

+ 1	(db-scale indication)
+30	(range switch position)
+31	(level in db as indicated by meter)
+ 8	(correction for 90-ohm impedance)
+39	dbm

3-26. For the same conditions, with the measurement made across 10,000 ohms:

+ 1	(db-scale indication)
+30	(range switch position)
+31	(level in db as indicated by meter)
-12.5	(correction for 10,000-ohm impedance)
+18.5	dbm

3-27. CURRENT MEASUREMENTS.

3-28. SHUNT RESISTORS

3-29. The hp Model 11029A through Model 11034A Shunt Resistors (table 1-2) are available to convert your Model 403B into a current measuring device. These resistors make possible current readings of from 1 μ amp to 3 amps full scale.

3-30. To use the Model 470 series resistors, proceed as follows:

a. Plug resistor into Model 403B input terminals.
b. Plug connector from circuit under test into shunt resistor.
c. Divide resistance value used into the reading on the Model 403B to get the actual current.

3-31. CLIP-ON PROBE

3-32. The hp Model 456A Current Probe provides quick measurement of current from 1 ma to 1 amp full scale with minimum circuit loading.

3-33. To use the Model 456A, simply clamp the probe around the current carrying wire and plug the output into the Model 403B. The probe output is 1 mv/ma.

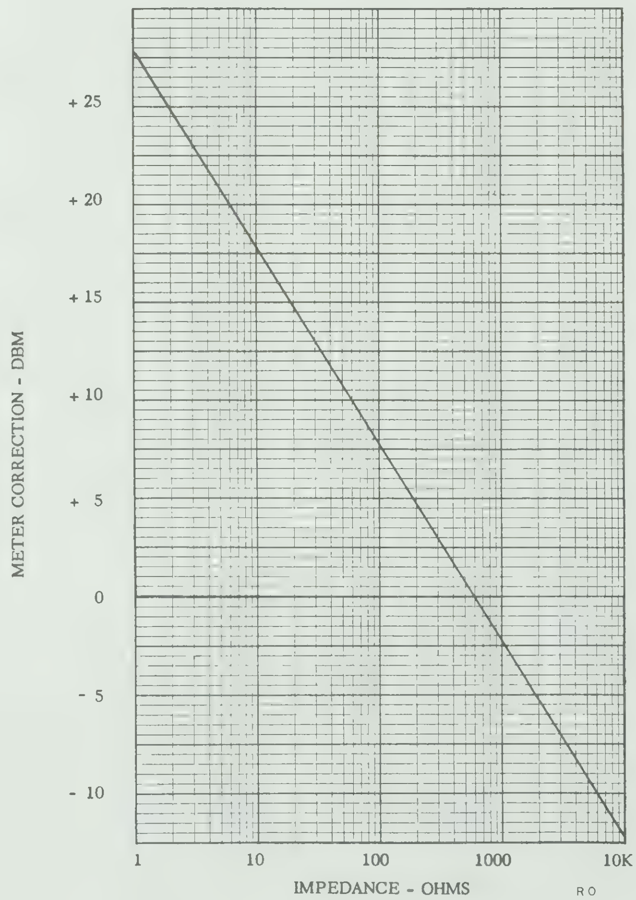


Figure 3-3. Model 403B Impedance Correction Graph

NOTES

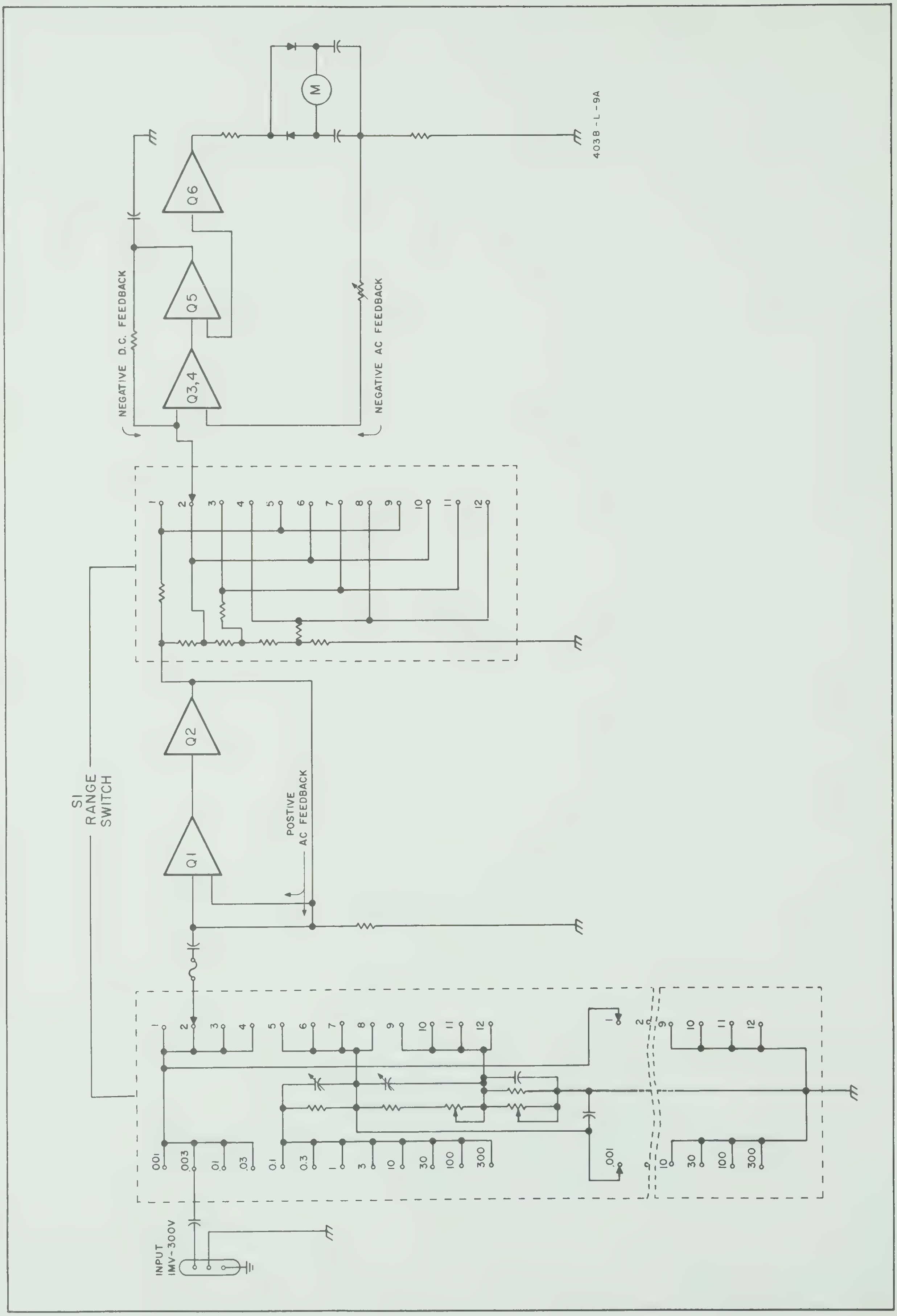


Figure 4-1. Model 403B Functional Block Diagram

SECTION IV
CIRCUIT DESCRIPTION

4-1. INTRODUCTION.

4-2. The Model 403B includes a preliminary input attenuator, a high impedance emitter follower circuit, a range attenuator and a wide range fixed gain amplifier. Refer to Figure 4-1.

4-3. PRELIMINARY ATTENUATOR.

4-4. The RANGE switch is divided up into two sections: the preliminary attenuator, located between the input terminals and Q1, and the intermediate attenuator, located between Q2 and Q3. The preliminary input attenuator has two ranges, 100:1 and 10,000:1, which are switched in at the appropriate time to keep the input voltage to Q1 less than 0.030 volt. This not only prevents overloading the input system, but also provides the necessary accurate attenuation to work with the intermediate attenuator to produce the conventional 1, 3, 10 sequence for correct meter operation.

4-5. The attenuators are of the compensated resistor-capacitor (rc) type, with the capacitive division ratio made equal to the resistive ratio to maintain a constant division ratio at all frequencies. By making one of the capacitors adjustable, the small variations in stray circuit capacity can be compensated for, so the voltmeter will have a flat response. The exact division ratio is set at low audio frequencies by the trimmer potentiometers, which bring the resistor division ratio to the exact value.

4-6. INPUT CIRCUIT.

4-7. R11, CR1, and CR2 make up a limiting circuit which is used for overload protection to prevent high instantaneous voltages from being impressed on the base of Q1. F1 is a 1/16 amp fuse used to protect the 403B against a continuous or repeated overload.

4-8. Since transistors are inherently low impedance devices, a need for a high input impedance is required. Referring to figure 4-2, it would seem that the input resistance of the first stage would be approximately R_i of a grounded collector configuration in parallel with R9, plus the R7-R8 combination. Q1 and Q2 are emitter followers, exhibiting unity gain and no phase reversal. (R_i = approx. input Z of a common collector stage.)

4-9. The output of Q2 is fed back to the junction of R9 and R7-R8. There is an ac voltage existing at this point that is very nearly the same amplitude as the input voltage. Since a very small ac voltage exists across R9, the input current I_{in} will be very small. Thereby:

$$Z_{in} = \frac{E_{in}}{I_{in}}$$

It can be seen that when I_{in} is very small, the apparent Z_{in} becomes very large.

4-10. The R_i of Q1 is increased in a similar manner by feeding the Q2 emitter voltage to both the collector and emitter of Q1.

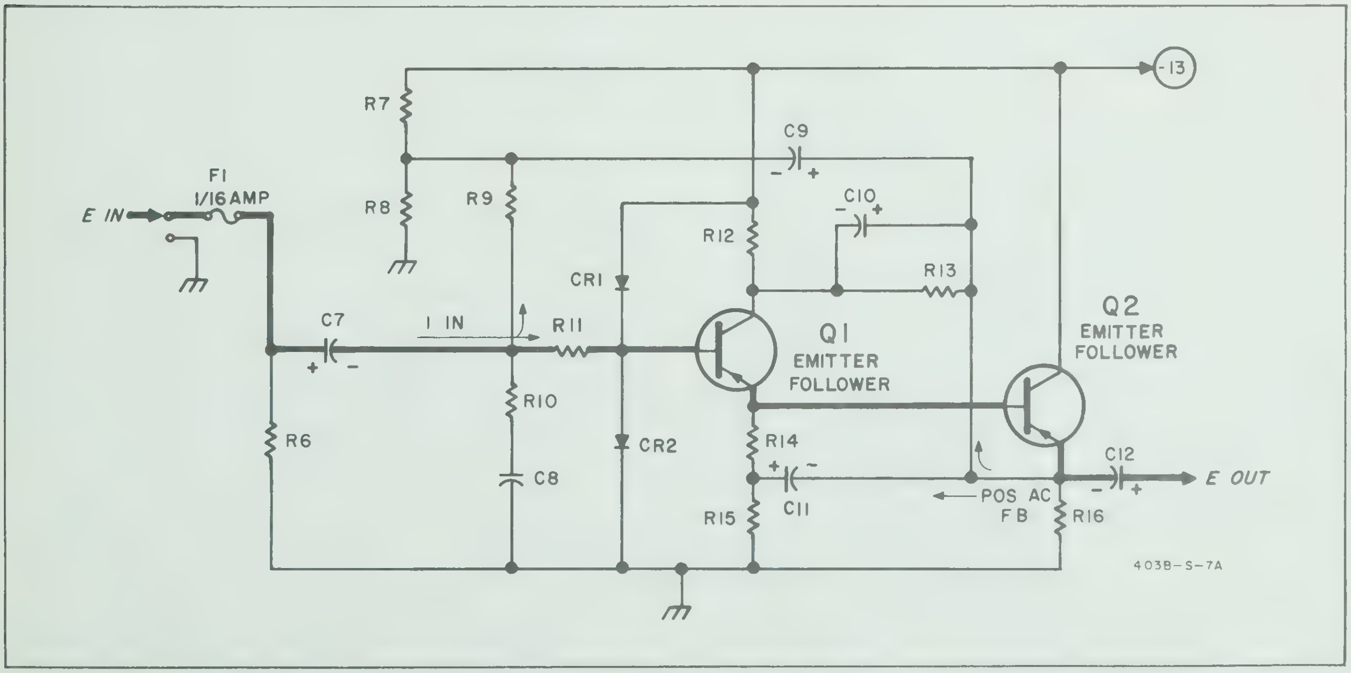


Figure 4-2. Input Amplifier

4-11. INTERMEDIATE ATTENUATOR.

4-12. The output of Q2 is fed to the intermediate section of the range attenuator. The range attenuator is a voltage divider, in sequence with the preliminary attenuator. A (1, 3, 10, etc.), ratio is obtained resulting in 10 DB steps. Refer to Figure 4-1.

4-13. Refer to schematic diagram (Figure 5-11) in the back of this manual.

4-14. Transistors Q3 through Q6 make up the fixed gain amplifier which is used to develop the current for (full scale) meter deflection and to provide the meter circuit with a high impedance source for linear operation at all current levels.

4-15. The output of the intermediate range attenuator is fed to the base of Q3 (differential amplifier), and compared with a feedback signal to its emitter from the meter circuit. This difference signal is fed to Q4 which in turn is directly coupled to Q5 and Q6. Q4 is a grounded emitter amplifier. Q5 is a common collector amplifier which impedance matches Q6, a common base amplifier. The direct couple feature of the amplifiers is necessary because of the low-frequency (5 cycle) response of the 403B. R24 through R26 make up the dc feedback loop which tends to minimize any tendency for dc drift due to ambient temperature change. R33 corrects the total gain of Q3 through Q6.

4-16. The meter source impedance is increased by the use of negative feedback from the output of the meter rectifier bridge to the emitter of Q3. Resistor R28 through R30, and C15 and C16 correct the phase of the feedback at high frequencies.

4-17. The necessity of high meter source impedance can be explained by referring to figures 4-3 and 4-4.

4-18. To have correct voltmeter action it is necessary that the change in meter current be proportional to a change in amplifier input voltage. The load resistance, then, should remain constant. Note in figure 4-3, however, that when I_o (and therefore the diode voltage E_d) decreases, the diode resistance R_d (and therefore the load resistance) increases, affecting meter linearity. Note in figure 4-4 that R_d appears in series with R_o, the source impedance. The effect on output current, due to changes in diode resistance with voltage, can be minimized by feeding the meter circuit from a constant current or high impedance source. In this way, changes of diode resistance will have a negligible effect on the total current passing through them and hence through the meter.

4-19. The effect of diode resistance change is further minimized by Q6 current through R35 which impresses a fixed 0.3 volt across CR3 and CR4, biasing them close to their contact potential.

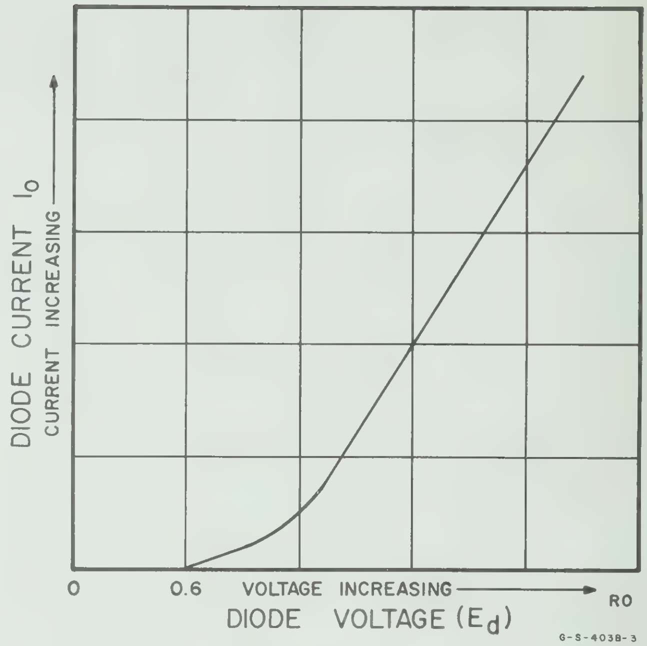


Figure 4-3. Diode Current Vs Diode Voltage

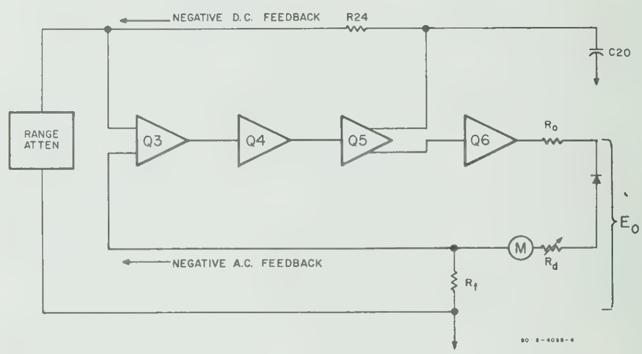


Figure 4-4. Fixed Amplifier Block Diagram

4-20. METER RECTIFIER CIRCUIT.

4-21. The meter rectifier circuit is arranged in a bridge-type configuration, with a crystal diode and a capacitor in each branch and a dc microammeter connected across its midpoints. The current through the meter is proportional to the average value of the input voltage waveform. Since calibration of the meter in rms volts is based on the ratio that exists between the average and effective values of a sine-wave voltage.

4-22. The 403B meter rectifier circuit operation can best be explained by analyzing the circuit in a simpli-

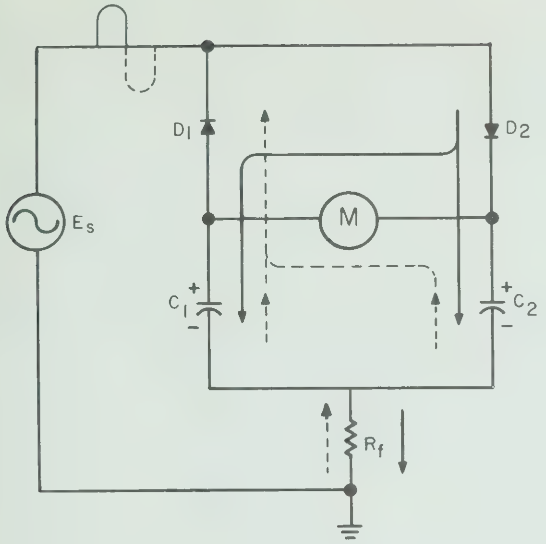


Figure 4-5. Meter Rectifier, Simplified Diagram

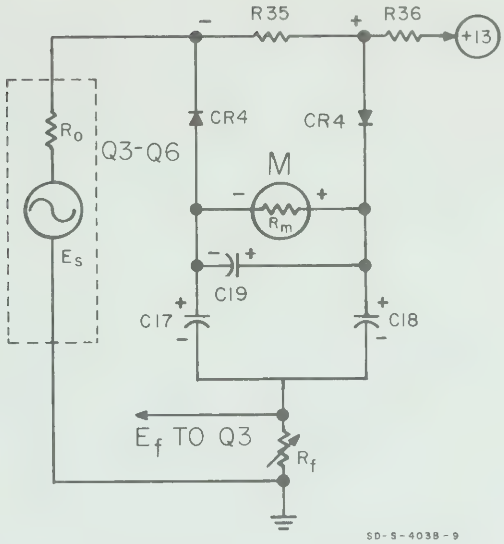


Figure 4-6. Meter Rectifier Circuit

fied form. Figure 4-5 shows a voltage source generating a voltage E_S across a circuit made up of CR1, CR2, M1, R_f, and C_1, C_2. Note that the current flow for each half cycle (as indicated by the arrows) always passes through the meter in the same direction.

4-23. In this circuit, disregarding contact potential and assuming zero meter resistance, the circuit could be considered as a small resistance made up of CR1 and CR2, in series with one capacitor ($C_1 + C_2$) in series with R_f. Therefore, there will be a voltage across R_f proportional to the input signal.

4-24. In the actual 403B meter rectifier circuit, capacitors C17 and C18 provide a path for the AC feedback loop. The generator (Q3-Q6) with its large internal impedance (R_o) develops a voltage across the bridge. The meter is deflected according to the average value of the input voltage. The signal across R_f as in figure 4-6 provides negative feedback, resulting in extremely linear meter operation and large R_o.

4-25. POWER SUPPLY.

4-26. The Model 403B operates on batteries only. This instrument uses four 6.5 volt nickel cadmium batteries and is designed to have a battery life of 40 hours before recharging.

4-27. R39 has been adjusted at the factory for a charging rate of 6.2 ma to prolong battery life. If the instrument is used frequently in the field, R39 can be adjusted for a charging rate of 11 ma.

CAUTION

If R39 is adjusted to the 11 ma rate the instrument should be used on BATTERIES ONLY except when recharging batteries. Recharging of batteries is accomplished whenever the 403B is connected to an AC source. The battery life of the instrument can be prolonged at the 11 ma charging rate if the instrument is not continuously overcharged.

4-28. When the function switch is in the BATT TEST position, and the instrument indicates a battery voltage of 2.4 volts, recharge the batteries for 20 to 25 hours at the 11 ma rate to completely recharge the batteries in the instrument. A longer charging period (not to exceed 30 hours) will be required if the batteries have been allowed to discharge below 24 volts.

4-29. Figure 5-8 illustrates the battery charger, showing 5.5 ma of current flowing through the instrument and 5.5 ma of current through the batteries. R39 is used to control the amount of current used to charge the batteries and caution must be used if R39 is adjusted to maximum charging rate.

CAUTION

The four nickel-cadmium batteries in the hp 403B are in hermetically sealed containers. The user must be cognizant of temperature extremes while charging the batteries. Under high temperatures (above 50^{o} Centigrade), hydrogen in the hermetically sealed battery container can build up large pressure causing damage to the batteries and/or instrument. DO NOT CHARGE BATTERIES ABOVE 40^{o} Centigrade or 104^{o} Fahrenheit, if R39 is set above 6.2 ma charging rate.

4-30. Figure 5-11 illustrates a conventional power supply. For 115 volt operation the power transformer primaries are connected in parallel, and in series when used for 230 volt operation. The rectifier circuit is a conventional full wave bridge using C21 for a filter capacitor. Diode CR9 (7 volt breakdown diode) and Q7 make up the Constant Current Generator. The collector current of Q7 is equal to the voltage across CR9 divided by R37 and R39.

4-31. CR10 prevents the batteries from discharging to the charging circuit when the instrument is in the OFF position.

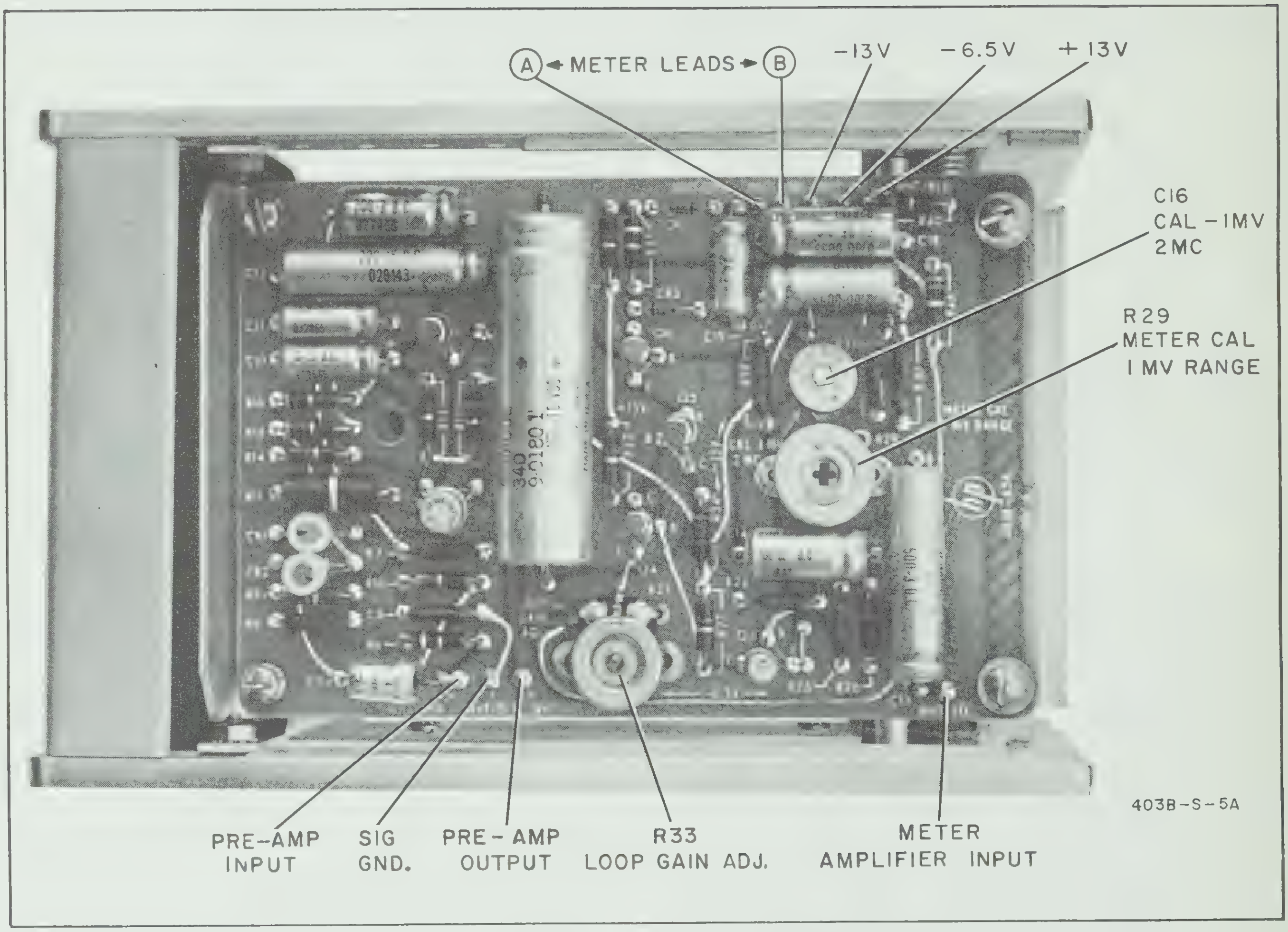


Figure 5-1. Model 403B Top View

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains test and maintenance information for your 403B. Included is a quick performance check that may be made with the instrument in its cabinet, as a part of routine maintenance or as a part of incoming quality control inspection.

5-3. This instrument should require very little maintenance. Should failure occur, however, a troubleshooting paragraph (5-10) has been included to assist in locating the failure. An exploded view of the Model 403B is given in figure 5-4 to help in locating parts.

5-4. Transistors, being inherently long-lived devices, should not require replacement in the life of the instrument. If it becomes apparent, through systematic troubleshooting, that replacement is necessary, care should be taken not to damage the etched circuit board.

5-5. Errors may be introduced in the 403B because of the capacity added in the circuit after cabinet replacement. Therefore, after making gain or frequency response adjustments, temporarily place covers back on instrument and recheck the adjustment.

5-6. TEST INSTRUMENTS REQUIRED.

5-7. Table 5-1 gives the test equipment required to check the 403B.

Table 5-1. Test Instruments Required

Instrument Type	Minimum Required Specifications	Recommended hp Instruments
DC Electronic Voltmeter	Sensitivity: 1 volt full scale minimum Input resistance: 10 megohms or higher	Model 412A Vacuum Tube Voltmeter
Voltmeter Calibration Generator	Output voltage range: .001 to 300 volts Signal frequency: 400 cps Distortion: less than 0.2%; Accuracy: ±0.25%	Model 738AR Voltmeter Calibrator
Frequency Response Test Oscillator	Output voltage: 3 volts into 50 ohms Frequency range: 300 kc to 10 mc Monitor meter accuracy: ±0.5%, 10 cps to 1 mc Other necessary features: 1) provision for use with external oscillator; 2) output step attenuator	Model 739AR Frequency Response Test Set
General Purpose Oscillator (low output impedance)	Frequency range: 5 cps to 600 kc Maximum output: 3 volts into 50 ohms Distortion: 0.5% below 500 kc	Model 200SR Oscillator
General Purpose Oscillator	Frequency range: 5 cps to 600 kc Maximum output: 20 volts open circuit Distortion: 0.5% below 500 kc	Model 200CD Wide Range Oscillator
AC Electronic Voltmeter	Input impedance: 10 megohms shunted by 25 pf (below the 0.3 volt range) Accuracy: ±2% from 20 cps to 1 mc	Model 400D/H/L Vacuum Tube Voltmeter
Clip On DC Milliammeter	Current Range: 3 ma to 1 ampere Accuracy: ±3% ±0.1 ma	Model 428A/B DC Milliammeter

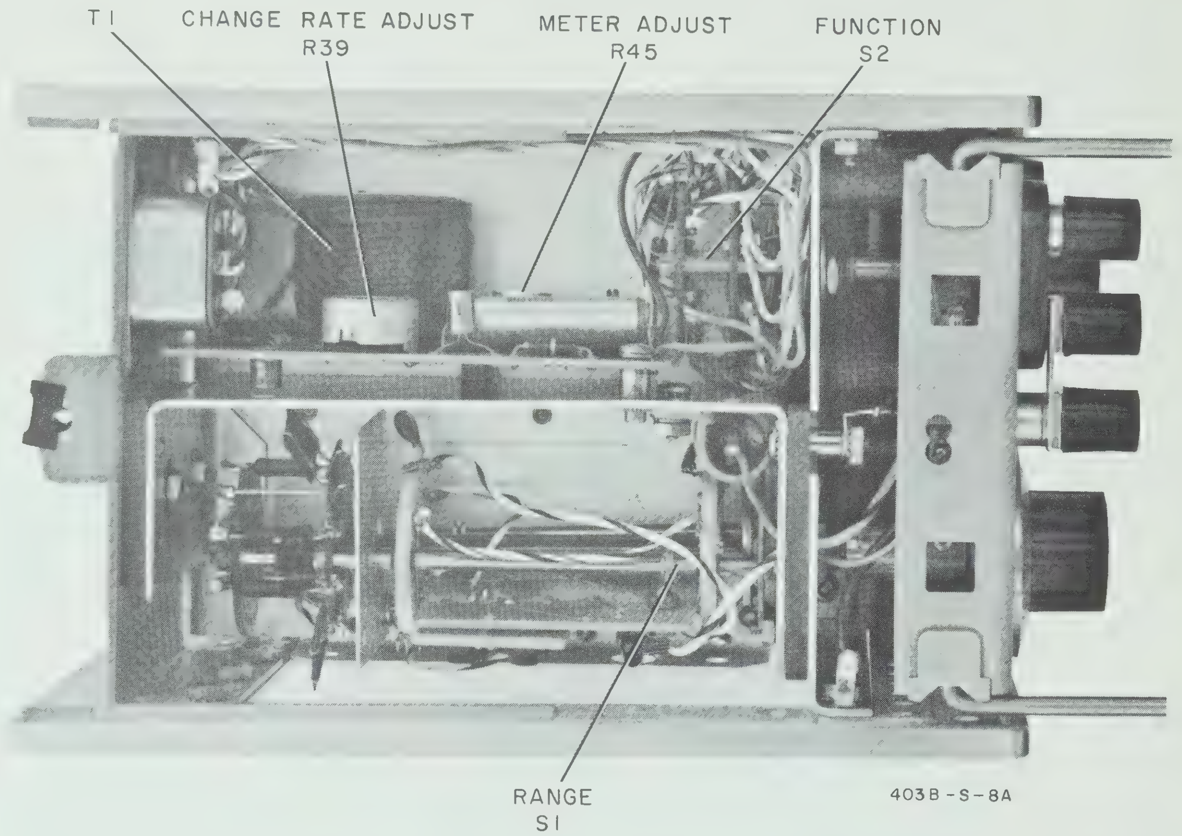


Figure 5-2. Model 403B Bottom View

5-8. METER, MECHANICAL ZERO.

5-9. When the meter is properly zero-set, the pointer will rest over the zero mark on the meter scale when the Voltmeter is 1) at normal operating temperature, 2) in its normal operating position, and 3) turned off. Zero-set as follows to obtain best accuracy and mechanical stability.

a. Allow the Voltmeter to operate for at least 20 minutes; this allows the meter movement to reach normal operating temperature.

b. Turn Voltmeter off and allow 30 seconds for all capacitors to discharge.

c. Rotate mechanical zero-adjustment screw clockwise.

d. Continue to rotate adjustment screw clockwise; STOP when pointer is right on zero.

5-10. TROUBLESHOOTING.

5-11. To assist in troubleshooting, tables 5-2 and 5-3 are included in this section of the manual. Table 5-2, Troubleshooting, is used for evaluating problems that may be encountered and easily recognized by the operator, and therefore consists mainly of front-panel indications. Table 5-2 and 5-4, Test Procedure Troubleshooting, is for the technician to localize areas of trouble encountered while testing the Model 403B.

NOTE

When replacing any crystal diodes or transistors in the Model 403B, refer to paragraph 5-16 and Table 5-4.

Table 5-2. Troubleshooting

Symptom	Cause
No response to input	Fuse F1 blown Batteries low Shorted transistor CR1 or CR2 shorted Open contacts in range switch
Low reading on Batt. test	Recharge Batteries
Noise indication on known quiet source	CR1 or CR2 noisy Noisy transistors (usually Q1 or Q2) CR3 or CR4
Meter pins .hen switching through ranges	Dirty contacts in range switch C7, C12, or C13 leaky
Meter pulsates at frequencies below 15 cps	C17, 18, 20 open or leaky
Meter calibration off on ranges above 0.03	Resistors or capacitors bad in range switch
Meter calibration off on ranges below 0.1	Resistors bad in intermediate attenuator Dirty contacts in range switch
Battery will not hold charge	CR10 shorted Shorted cell in battery
Battery charge inoperative	Q7, CR5, CR6, CR7, CR8, CR9, C21 Switch on 230V position when using 110V
0.001, 0.1, 10 calibration okay but all other ranges out of calibration at 400CPS	Replace C13
If all ranges on 400CPS calibration check out okay except for one or two ranges and the stick resistors check okay	Change Q3
3 volts 2 nc meter reads high	Shorten leads on R18. If this doesn't fix problem, replace R18
No adjustment on charging current	Check for solder splashes on backside of R39

5-12. REPAIR.

5-13. CABINET REMOVAL.

a. Top Cover: remove the single screw which holds the cover to the rear panel and slide the cover toward the rear.

b. Bottom Cover: remove the flat head screw holding the cover to the rear panel and slide the cover toward the rear. The bail must be up.

c. Side Covers: remove the flat head screws which hold the cover to the side casting of the instrument.

Table 5-3. Test Procedure Troubleshooting

Symptom	Cause
R29 will not adjust for full scale indication	CR1, 2 CR3, 4 bad Q1 through Q6 bad
Noise (403B input terminated with a shielded 100K resistor)	Usually Q1 or Q2 noisy
Input resistance out of specs	Q1 or Q2 bad C9, C10, C11, R6
Meter does not track properly	
1) Meter reads consistently above or below all meter divisions	CR3, CR4 bad R35 wrong value
2) Meter reads above some but below other divisions	Diodes CR3, CR4 bad Meter M1 bad
Low frequency response bad	CR1, 7, 12, 13, 18-20 or C31, 32 leaky
400D reads more than 1.5 volts on overload	CR1 or CR2 bad
Excessive Charging Rate R39 No Effect	Bad CR9, Q7

5-14. SERVICING ETCHED CIRCUIT BOARDS.

5-15. Two single-sided and one double-sided circuit board is used in the Model 403B. When servicing this board, these general rules should be followed:

a. Do not apply excessive heat to the conductor or component being soldered.

b. Use a toothpick or wooden splinter to clean holes before inserting new components.

c. To remove a damaged component, clip leads near component; then apply heat and remove component lead with a straight upward motion.

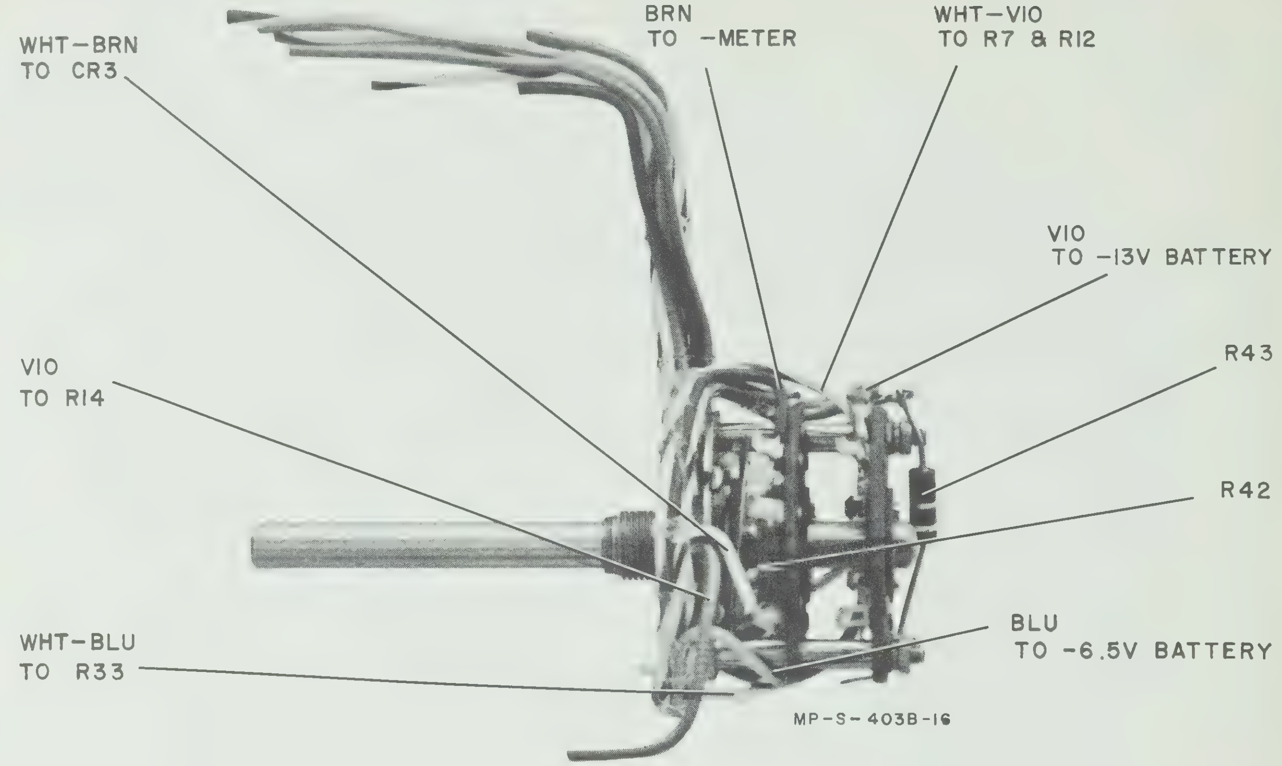
d. To insure good connection between the eyelet and conductor, solder from the conductor side.

5-16. TRANSISTOR REPLACEMENT.

5-17. Transistors can be damaged by excessive heat. When replacing transistors on the Model 403B printed circuit board, follow the instructions given in Paragraph 5-14. Refer to Table 5-4 for any adjustments after replacement.

5-18. FUNCTION SWITCH REPAIR.

5-19. Figure 5-3 gives parts location and cabling detail on Model 403B FUNCTION switch.



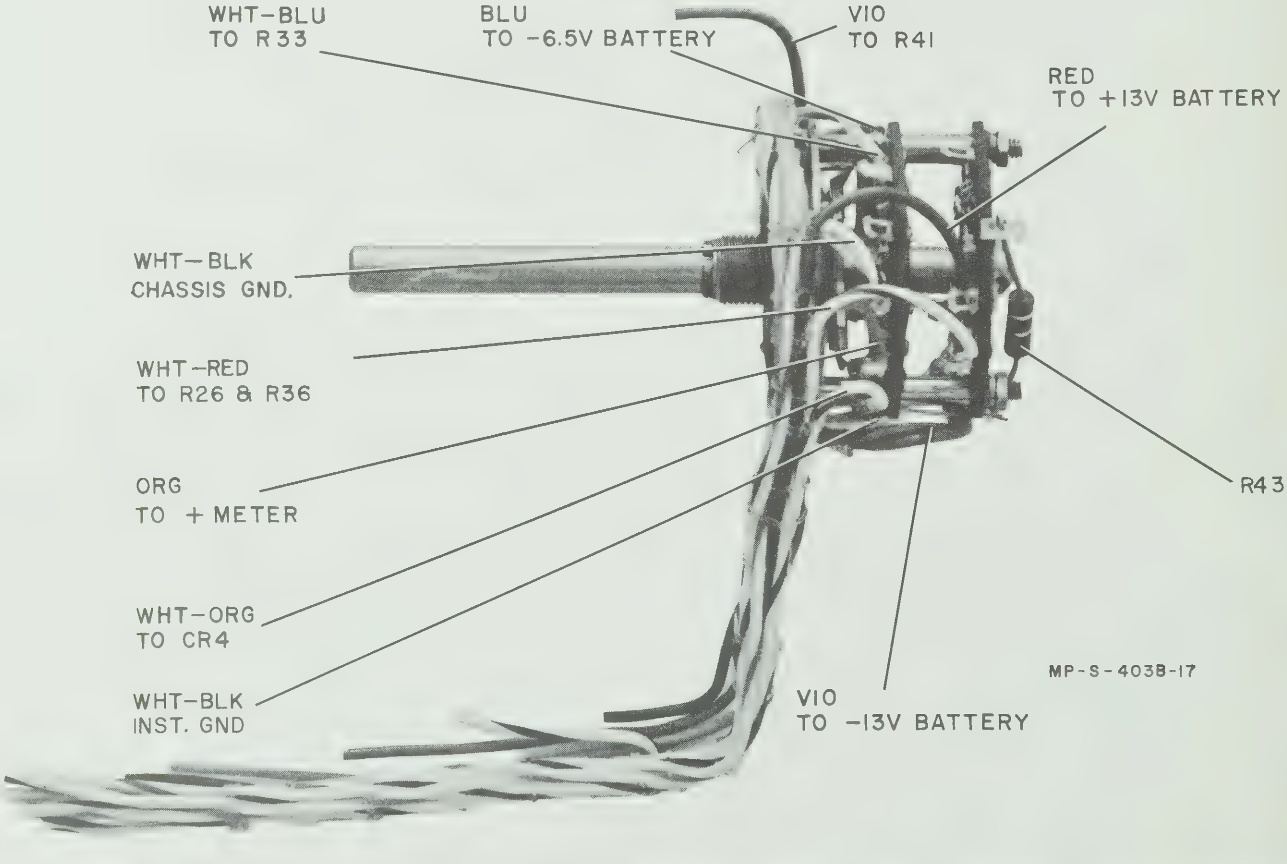


Figure 5-3. Function Switch Detail

Table 5-4. Transistor Replacement

Reference	Function	Checks or Adjustments Req.	Refer to Paragraph
Q1, 2	Q1 and Q2 work together to provide a high input impedance (Emitter Follower)	Check input impedance Readjust R29 Check noise	5-43 steps a thru d 5-30 steps c & d 5-26 steps a thru c
Q3, 4 Q5 Q6	Amplifier (Common emitter) Amplifier (Common collector) Amplifies signal (Common base)	Readjust R33 Readjust R33 Readjust R33	5-31 steps a thru g 5-31 steps a thru g 5-31 steps a thru g
CR1, 2	Protects Q1 from overload	Recheck overload characteristics Check noise	5-34 steps a thru c 5-26 steps a thru c
CR3, 4	Meter Diodes	Readjust R29 Readjust R45	5-30 steps c & d 5-29 steps c & d
CR5, CR9 CR10	Rectifier Diodes Zener Diode Isolation Diode	Check battery charge current Readjust R39 Check battery charge current	5-29 steps f & g 5-29 steps f & g 5-29 steps c & d
Q7	Charging Current Regulation	Readjust R39	5-29 steps f & g

5-20. FLUORESCENT INDICATOR DECAL.

5-21. If the FUNCTION switch is removed for any reason, the fluorescent indicator decal will have to be replaced. This decal has a special adhesive on the back that holds firmly against the FUNCTION switch nut. To assure positive contact, proceed as follows:

a. Moisten the back of the decal with a piece of tissue soaked in xylene and allow a few minutes for the adhesive to soften.

b. Place the decal over the FUNCTION switch shaft, adhesive side down. Position the black area directly over the OFF line on the Model 403B panel and press the decal firmly against the FUNCTION switch nut.

c. Slide a bushing or nut over the shaft so that it will hold the decal in contact with the FUNCTION switch nut, and allow about 20 minutes for the adhesive to dry.

d. Remove the bushing or nut used for weighting and install the small spacer and FUNCTION switch knob.

5-22. ADJUSTMENTS.

5-23. The following is a complete test and adjustment procedure and should be made only if it has been definitely determined that the Model 403B is out of adjustment. Transistor changes are usually not cause for complete adjustment (see Table 5-4). If the instrument fails to make any one of the limits given in the following steps, carefully recheck your connections and procedure. If the instrument still fails the step, refer to Table 5-2 and 5-3 for possible cause and corrective action.

5-24. In order to avoid the effects of hand capacity, a tuning wand and tuning screwdriver with a plastic shank should be used for all adjustments.

5-25. POWER SUPPLY.

a. Connect the Model 403B to a variable line transformer. Set line voltage to 115 volts; turn on the AC Voltmeter, and allow five minutes for warm up.

b. Connect a Clip-On DC Ammeter (hp Model 428A/B) probe around the violet wire connected to battery BT4. Adjust R39 (see Figure 5-2) for an indication of 6.2 ma on the DC Ammeter.

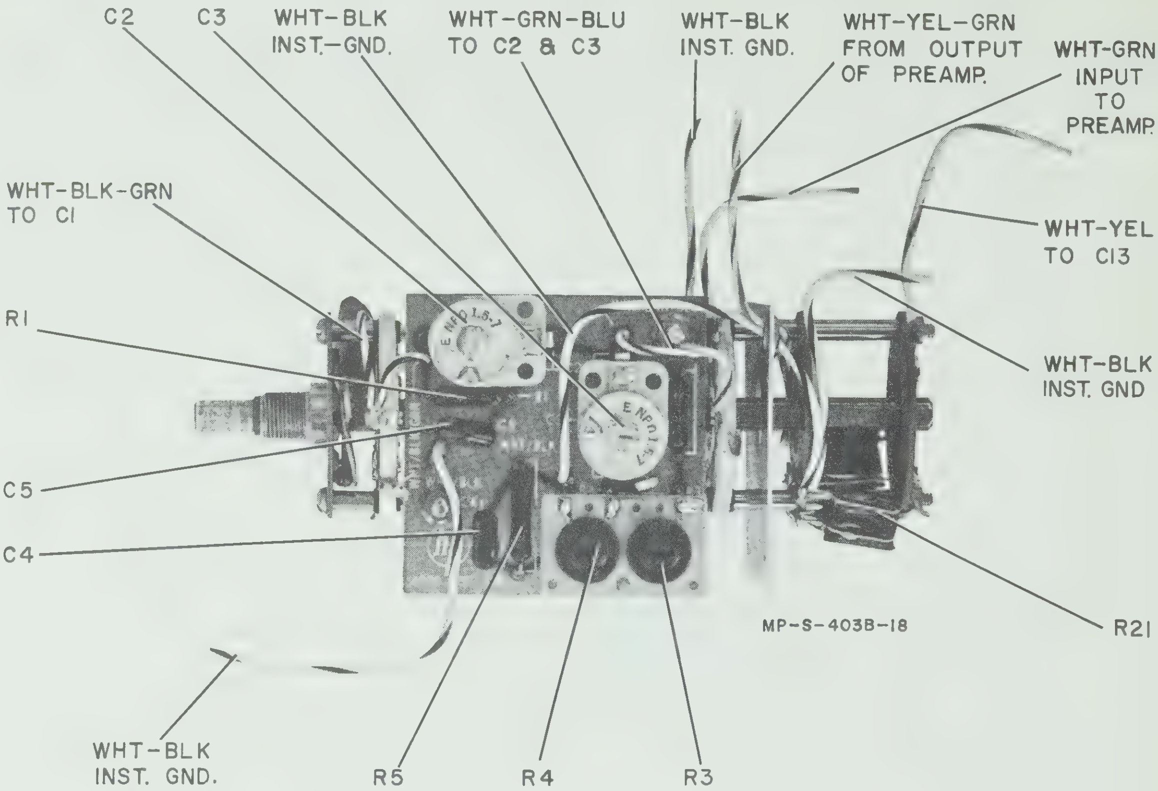
Note

If the instrument is to be used frequently in the field, R39 can be adjusted for a fast charging rate of 11 ma. Do not charge batteries at temperatures above 40°C if R39 is set for 11 ma charging rate. Battery life will be prolonged at the lower charging rate.

c. Vary input line voltage from 103 to 127 volts; the Clip-On DC Ammeter reading should not vary more than 1.0 ma from the reference setting in Step b.

d. Set line voltage to 115 volts. Connect an isolated AC Voltmeter (hp Model 400H) across the red (BT1) and violet (BT4) wires connected to the batteries; the ripple voltage should not exceed 1.5 mv.

e. Set Model 403B FUNCTION switch to OFF; disconnect AC Power source and set FUNCTION switch to ON.



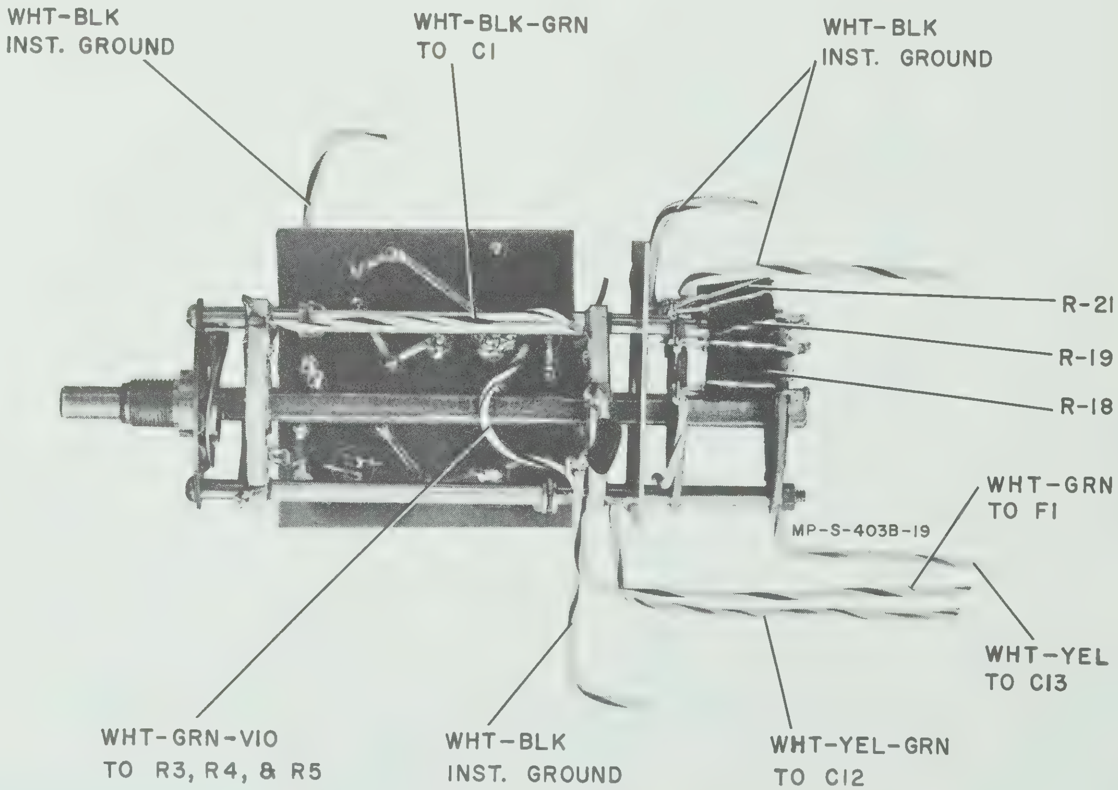


Figure 5-4. Range Switch Details

f. Connect volts probe of a DC Voltmeter (hp Model 412A) to red wire connected to battery BT1; connect common lead of DC Voltmeter to violet wire connected to battery BT4.

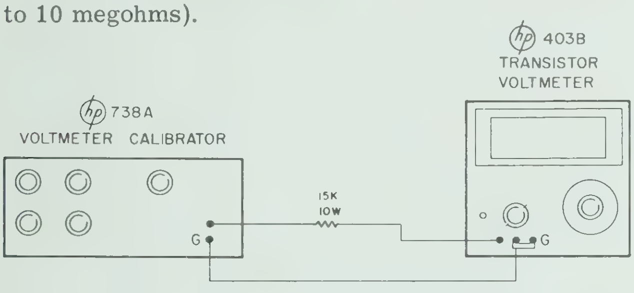
CAUTION

DC Voltmeter must be isolated from 403B ground.

g. Rotate 403B FUNCTION switch to BATT. TEST. If DC Voltmeter reading is not 24 volts, recharge batteries in 403B. (See Paragraph 3-7.) Adjust R45 for a 403B-meter indication equal to voltage indicated on DC Voltmeter.

5-26. INPUT RESISTANCE.

5-27. Check the Model 403B input resistance by following the procedure outlined in Paragraph 5-41. If input resistance is not within test limits, the value of R6 should be changed (typical range of R6 is from 3.9 to 10 megohms).



5-28. OVERLOAD CHECK.

a. Connect Model 403B as shown in Figure 5-5.

CAUTION

The 15K resistor must be connected as shown in Figure 5-6 to prevent damage to Voltmeter Calibrator.

b. Rotate 403B FUNCTION switch to OFF; connect an AC Voltmeter between the base of Q1 and chassis ground.

c. Rotate 403B FUNCTION switch to ON and RANGE switch to 0.1 volt.

d. Set Voltmeter Calibrator (hp Model 738AR) OUTPUT SELECTOR to 400 cps RMS and the MULTIPLIER and RANGE switches to 300 volts; the AC Voltmeter reading should be less than 3.5 volts. (If necessary, check CR1 and CR2.)

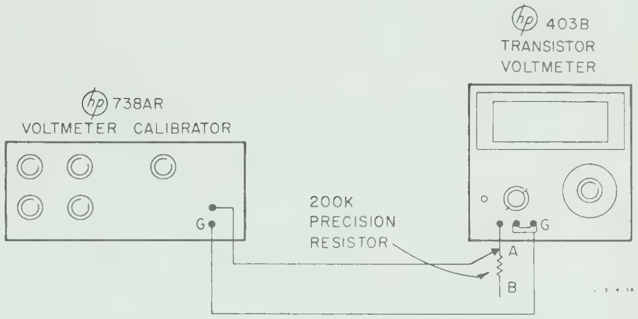


Figure 5-6. Performance Check Setup

5-29. TRACKING AND CALIBRATION.

a. Disconnect the 403B from the AC Power source. (The following procedure should be performed with battery operation.)

b. Connect Model 403B as shown in Figure 5-6 (Position A).

Note

The 200K resistor is used only for the input resistance check (Paragraph 5-26).

c. Rotate the 403B RANGE switch to 0.001 volt.

d. Set Voltmeter Calibrator (hp Model 738AR) FUNCTION and RANGE switches to 0.001 volt 400 cps RMS.

e. Preset R33 fully counterclockwise and adjust R29 (see Figure 5-1) for a full-scale indication on the 403B.

f. Rotate 403B RANGE switch to 0.1 volt. Set the Voltmeter Calibrator to 0.1 volt at 400 cps RMS.

g. Adjust R3 for a full-scale indication on the 403B meter.

h. Rotate 403B RANGE switch to 30.0 volts, and set Voltmeter Calibrator to 30.0 volts at 400 cps RMS.

j. Adjust R4 (see Figure 5-2) for a full-scale indication on the 403B meter.

k. Check calibration on the 0.003, 0.01, and 0.03 volt ranges; accuracy should be within ±1.0% of full scale on all ranges.

m. Rotate Voltmeter Calibrator FUNCTION switch to 1.0 volt TRACKING. Rotate 403B FUNCTION switch to 1.0 volt.

n. Check 403B meter tracking at 0.1 volt increments. Variation should be less than ±1% of full scale.

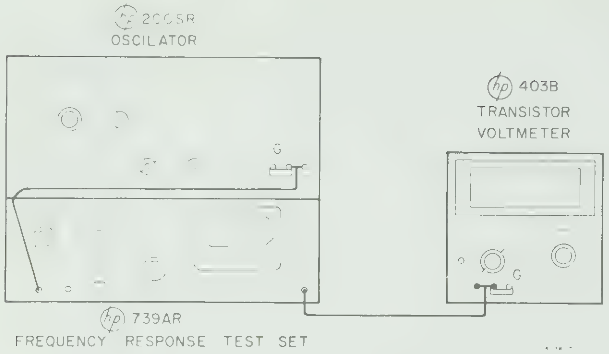


Figure 5-7. Frequency Response Setup

5-30. HIGH FREQUENCY RESPONSE.

a. Connect Model 403B as shown in Figure 5-7.

b. Set Frequency Response Test Set (hp Model 739AR) to EXTERNAL and adjust Oscillator (hp Model 200SR) frequency to 400 cps. Rotate 739A OUTPUT ATTENUATOR to 0.001 volt.

c. Adjust Oscillator AMPLITUDE control until 403B reads exactly 0.9 of full scale on the 0.001 volt range.

d. Adjust the 739A METER SET for a reference meter indication of SET LEVEL.

e. Rotate Test Set Range SELECTOR to the 1-3 mc range while maintaining the SET LEVEL on reference meter (using the Test Set AMPLITUDE control) and rotate FREQ. TUNING between 1 and 3 mc. Adjust C16 until the 403B meter indicates 0.9 mv ±5% at 2 mc and has a gradual roll-off between 2 and 3 mc. If C16 does not have sufficient range, the value of C15 should be changed (range of C15 is from 100 pf to 160 pf).

f. Adjust the Test Set RANGE selector and FREQ TUNING for a 300 kc output. Adjust AMPLITUDE control for a reference meter indication of SET LEVEL.

g. Rotate tuning knob on Test Set between 300 kc and 1 mc while maintaining SET LEVEL on reference meter. The 403B meter should read at 0.9 mv ±0.02 mv (±2%). If necessary, adjust R33 for a flat response.

Note

Repeat Paragraphs 5-29 thru 5-30, if R33 is adjusted.

h. Rotate 403B RANGE switch to 0.1 volt.

j. Rotate Test Set RANGE SELECTOR to EXTERNAL and adjust Oscillator Frequency to 400 cps. Rotate test set OUTPUT ATTENUATOR to the 0.1 volt range.

k. Adjust Oscillator AMPLITUDE control for an indication of 0.9 of full scale on the 403B meter.

m. Readjust the Test Set METER Set control for SET LEVEL on reference meter.

n. Rotate Test Set RANGE SELECTORS and FREQ TUNING for a 300 kc output while maintaining SET LEVEL on reference meter.

p. Adjust C2 for a 0.9 of full scale reading on 403B meter.

5-31. 30-VOLT RESPONSE.

a. Rotate 403B RANGE switch to 30.0 volts.

b. Connect Wide Range Oscillator (hp Model 200CD) to the 403B INPUT. Set the Oscillator frequency to 400 cps.

c. Connect an AC Voltmeter (hp Model 400H) to the Oscillator OUTPUT.

d. Adjust the Oscillator AMPLITUDE for 20.0 volt indication on the 403B meter. Record the AC Voltmeter (hp Model 400H) reading.

e. Set the Oscillator frequency to 600 kc. Adjust the Oscillator AMPLITUDE until the AC Voltmeter indicates the reference level recorded in Step d.

Note

The AC Voltmeter used in this procedure should have been recently calibrated and have a known frequency response from 400 cps to at least 600 kc. If there is a variation in response between 400 cps and 600 kc, this should be considered for when adjusting the 403B.

f. Adjust C3 for a 403B meter indication of 20.0 volts.

g. Repeat Paragraph 5-30, Steps h thru p, adjusting C2 and C3 for optimum performance between 0.1 volt range at 300 kc and 30 volt range at 600 kc.

5-32. LOW FREQUENCY RESPONSE.

5-33. Perform the procedure outlined in Paragraph 5-39.

5-34. PERFORMANCE CHECK.

5-35. The performance check is an in-cabinet check that is used to check instrument specification. All checks are made from the front panel. This procedure can also be used as an incoming or outgoing quality control check. Refer to Table 5-1, Test Equipment Required, throughout performance check.

Table 5-5. Calibration Table

Model 403B RANGE	Model 738AR MULTIPLIER	Model 738AR RANGE	Model 403B Reading	Tolerance + Volts
300	100	3	300	3
100	100	1	100	1
30	10	3	30	0. 3
10	10	1	10	0. 1
3	1	3	3	0. 03
1	1	1	1	0. 01
. 3	. 1	3	0. 3	3 mv
. 1	. 1	1	0. 1	1 mv
. 03	. 01	3	0. 03	0. 3mv
. 01	. 01	1	0. 01	0. 1 mv
. 003	. 001	3	3 mv	0. 03 mv
. 001	. 001	1	1 mv	0. 01 mv

5-36. CALIBRATION.

a. Rotate 403B FUNCTION switch to BATT TEST. Meter should read 2. 4 volts on the 3. 0 volt scale. If 403B does not read 2. 4 volts, recharge batteries.

b. Set RANGE to 300 VOLTS; FUNCTION to ON.

c. Connect 403B as shown in Figure 5-5.

d. Switch the Voltmeter Calibrator POWER on; set OUTPUT SELECTOR to 400 cps RMS.

CAUTION

Do not touch the Model 738AR OUTPUT terminals without first rotating the OUTPUT SELECTOR to OFF.

e. Adjust Voltmeter Calibrator MULTIPLIER and RANGE switches and 403B RANGE switch to check each range of the 403B. The 403B should read within ±1% of full scale on every range. (Use Calibration Table 5-5 for reference.)

5-37. HIGH FREQUENCY RESPONSE.

5-38. Check frequency response to 500 kc, 1 mc and 2 mc.

a. Connect ℎ𝑝 Model 403B as shown in Figure 5-7.

b. Rotate Model 739AR RANGE SELECTOR to EXTERNAL position, and adjust the Model 200SR Oscillator to 400 cps.

c. Rotate OUTPUT ATTENUATOR (V. T. V. M. SCALE) on the Model 739AR to the 0. 001 range.

d. Rotate the Model 403B RANGE switch to 0. 001 volt.

e. Adjust Model 200SR AMPLITUDE control for a reference of 0. 9 of full scale on the 0. 001 VOLT RANGE of the Model 403B.

f. Set Model 739AR reference meter to SET LEVEL with the METER SET control.

g. Adjust the RANGE SELECTOR and FREQ TUNING on Model 739AR for 500 kc. Set Model 739AR to SET LEVEL with the oscillator AMPLITUDE control. Model 403B should read 0. 9 of full scale ±2%.

h. Repeat Step g adjusting RANGE and FREQ TUNING for 1 mc.

j. Adjust RANGE SELECTOR and FREQ TUNING to 2 mc. Maintain the reference meter at SET LEVEL with test set AMPLITUDE control. The Model 403B meter should read 0. 9 of full scale ±5%.

k. Repeat Steps b thru j with the 403B and Test Set RANGE switches set to 0. 003, 0. 01, 0. 03, 0. 1, and 3. 0 volts.

5-39. LOW FREQUENCY RESPONSE.

a. Connect ℎ𝑝 Model 403B as shown in Figure 5-7.

b. Rotate 403B RANGE switch to 0. 001 volt.

c. Rotate Test Set RANGE SELECTOR to EXTERNAL and OUTPUT ATTENUATOR to 0. 001 volt.

d. Set Oscillator frequency to 400 cps and adjust AMPLITUDE for an indication of 0. 9 of full scale on 403B meter.

e. Adjust Test Set meter SET LEVEL to a convenient reference mark.

f. Set Oscillator frequency to 10 cps and adjust the AMPLITUDE control to maintain the reference level set in Step e. The 403B meter should indicate 0. 9 of full scale ±2%.

g. Set Oscillator frequency to 5 cps and adjust the AMPLITUDE control to maintain the reference level to Step e. The 403B meter should indicate 0. 9 of full scale ±5%.

h. Repeat Steps a thru g with 403B and Test Set RANGE switch settings of 0. 003, 0. 01, 0. 03, 0. 1, and 3. 0 volts.

5-40. NOISE CHECK.

a. Rotate Model 403B FUNCTION switch to ON.

b. Terminate the 403B input with a 100 k ohm-shielded load. Model 403B meter deflection should be less than 3% with battery operation and less than 8% on any range with AC operation.

5-41. INPUT RESISTANCE.

a. Connect the Model 403B as shown in Figure 5-6 (Position B).

b. Rotate 403B RANGE switch to 0.01 volt.

c. Adjust Voltmeter Calibrator RANGE and MULTIPLIER switches for an output of 0.01 volt 400 cps RMS.

d. The 403B meter should indicate between 7.5 and 9.5 mv.

Note

This corresponds to an input resistance of 1.5 to 2.5 megohms where:

$$R \text{ input} = \frac{Eo}{0.01 - Eo} \times 200,000 \text{ ohms}$$

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts. Table 6-1 lists in alpha-numerical order of their reference designators and indicates the description and ⓗⓟ stock number of each part, together with any applicable notes. The parts not used in conjunction with designated components are under miscellaneous. Table 6-2 lists parts in alpha-numerical order of their ⓗⓟ stock numbers and provides the following information on each part:

a. Description of the part (see list of abbreviations below).

b. Typical manufacturer of the part in five-digit code; see list of manufacturers in appendix.

c. Manufacturer's stock number.

d. Total quantity used in the instrument (TQ column).

e. Recommended spare part quantity for complete maintenance during one year of isolated service (RS column).

6-3. Miscellaneous parts not indexed in Table 6-1 are listed at the end of Table 6-2.

6-4. ORDERING INFORMATION.

6-5. To order a replacement part, address order or inquiry to your Hewlett-Packard field office. A map with field office locations and their addresses is given in the Appendix of this manual.

6-6. Specify the following information for each part:
a. Model and complete serial number of instrument.
b. Hewlett-Packard stock number.
c. Circuit reference designator.
d. Description.

6-7. To order a part not listed in Table 6-1 and 6-2, give a complete description of the part and include its function and location.

REFERENCE DESIGNATORS

A	= assembly	F	= fuse	P	= plug	V	= vacuum tube, neon bulb, photocell, etc.
B	= motor	FL	= filter	Q	= transistor	W	= cable
C	= capacitor	J	= jack	R	= resistor	X	= socket
CR	= diode	K	= relay	RT	= thermistor	XF	= fuseholder
DL	= delay line	L	= inductor	S	= switch	XDS	= lampholder
DS	= device signaling (lamp)	M	= meter	T	= transformer	Z	= network
E	= misc electronic part	MP	= mechanical part				

ABBREVIATIONS

a	= amperes	elect	= electrolytic	mtg	= mounting	rot	= rotary
bp	= bandpass	encap	= encapsulated	my	= mylar	rms	= root-mean-square
bwo	= backward wave oscillator	f	= farads	NC	= normally closed	rmo	= rack mount only
c	= carbon	fxd	= fixed	Ne	= neon	s-b	= slow-blow
cer	= ceramic	Ge	= germanium	NO	= normally open	Se	= selenium
cmo	= cabinet mount only	grd	= ground (ed)	NPO	= negative positive zero (zero temperature coefficient)	sect	= section(s)
coef	= coefficient	h	= henries	nsr	= not separately replaceable	Si	= silicon
com	= common	Hg	= mercury	obd	= order by description	sil	= silver
comp	= composition	impg	= impregnated	p	= peak	sl	= slide
conn	= connection	incd	= incandescent	pc	= printed circuit board	td	= time delay
crt	= cathode-ray tube	ins	= insulation (ed)	pf	= picofarads = 10^{-12} farads	TiO_2	= titanium dioxide
dep	= deposited	K	= kilo = 1000	pp	= peak to peak	tog	= toggle
EIA	= Tubes or transistors meeting Electronic Industries' Association standards will normally result in instrument operating within specifications; tubes and transistors selected for best performance will be supplied if ordered by ⓗⓟ stock numbers.	lin	= linear taper	piv	= peak inverse voltage	tol	= tolerance
		log	= logarithmic taper	pos	= position (s)	trim	= trimmer
		m	= milli = 10^{-3}	poly	= polystyrene	twt	= traveling wave tube
		M	= megohms	pot	= potentiometer	var	= variable
		ma	= milliamperes	rect	= rectifier	w/	= with
		μ	= micro = 10^{-6}			W	= watts
		minat	= miniature			ww	= wirewound
		mfgl	= metal film on glass			w/o	= without
		mfr	= manufacturer			*	= optimum value selected at factory, average value shown (part may be omitted)

Table 6-1. Index by Reference Designator

Circuit Reference	ⓗ Stock No.	Description	Note
A1	403B-65A	Assy, printed circuit: includes, C7 thru C20, CR1 thru CR4, Q1 thru Q6, R6 thru R16, R24 thru R36, R40, R46	
A2	403B-65B	Assy, resistor board: includes, C21, CR5 thru CR10, T1, Q7, R37 thru R39, R41, R44, R45, R47	
A3	403B-65C	Assy, resistor board: includes, C2 thru C5, R1 thru R5	
BT1, 2, 3, 4	1420-0015	Battery, Nickel Cadmium, 6.5V nom. 225 mah	
C1	0170-0033	C: fxd, 0.18 µf ±10%, 600 vdcw	
C2, C3	0130-0003	C: var, cer, 1.5-7 pf ±10%, 500 vdcw	
C4	0140-0151	C: fxd, mica, 820 pf ±2%, 300 vdcw	
C5	0140-0178	C: fxd, mica, 560 pf ±2%, 300 vdcw	
C6	0140-0145	C: fxd, mica, 22 pf ±5%, 500 vdcw	
C7	0180-0008	C: fxd, elect., 4.0 µf -15% +20%, 60 vdcw	
C8	0160-0205	C: fxd, mica, 10 pf ±5%, 500 vdcw	
C9	0180-0060	C: fxd, elect., 200 µf -10% +100%, 3 vdcw	
C10	0180-0059	C: fxd, elect., 10 µf, 10 vdcw	
C11	0180-0064	C: fxd, elect., 35 µf -10% +100%, 6 vdcw	
C12	0180-0104	C: fxd, elect., 200 µf, 15 vdcw	
C13	0180-0063	C: fxd, elect., 500 µf -10% +100%, 3 vdcw	
C14	0180-0039	C: fxd, elect., 100 µf, 12 vdcw	
C15	0140-0216	C: fxd, mica, 120 pf ±2%, 300 vdcw	
C16	0130-0017	C: var, cer, 8-50 pf, 500 vdcw	
C17, C18	0180-0058	C: fxd, elect., 50 µf -10% +100%, 25 vdcw	
C19	0180-0033	C: fxd, elect., 50 µf, 6 vdcw	
C20	0180-0150	C: fxd, elect., 1200 µf, 10 vdcw	
C21	0180-0149	C: fxd, elect., 65 µf, 60 vdcw	
CR1, CR2	1901-0044	Diode, Si	
CR3, CR4	1901-0027	Diode, Si	
CR5, 6, 7, 8, 10	1901-0025	Diode, Si, 50 ma, 100 piv	
CR9	1902-0108	Diode, Breakdown	
DS1	1450-0048	Indicator, Neon	
F1	2110-0011	Fuse, 1/16 amp, 250 v maximum, 5.4 ohm	
J1		Terminals, three, female	
	1510-0008	Assy, Binding Post: Red	
	1510-0009	Assy, Binding Post: Black	
	5060-0626	Assy, Binding Post: Black w/strap	
	0340-0090	Insulator, B. P. Double Keyed	
J2	1251-0148	Connector: power, 3 pin male	
M1	1120-0315	Meter, 0-100 µa dc (403B)	
	1120-0316	Meter, 0-100 µa dc, DB Scale (403B-db)	
Q1	1850-0060	Transistor PNP	
Q2, 3, 5	1850-0096	Transistor, PNP, 2N2189	
Q4, 6	1854-0017	Transistor, NPN, 2N706A	
Q7	1850-0064	Transistor, PNP, 2N1183	

See introduction to this section

Table 6-1. Index by Reference Designator (cont'd)

Circuit Reference	ⓗ Stock No.	Description	Note
R1	0727-0287	R: fxd, comp, 2 Meg ±1%, 1/2 W	
R2	0727-0443	R: fxd, comp, 19.1K ±1%, 1/2 W	
R3, 4	2100-0390	R: var, comp, duel, 2K and 6K ohms, 1-1/4 W	
R5	9727-0056	R: fxd, mfgl, 216 ohms ±1/2%, 1/2 W	
R6	0687-4751	R: fxd, comp, 4.7M ±10%, 1/2 W	
R7	0758-0051	R: fxd, comp, 43K ±5%, 1/2 W	
R8	0758-0022	R: fxd, comp, 82K ±5%, 1/2 W	
R9	0687-1541	R: fxd, comp, 150K ±10%, 1/2 W	
R10	0687-4721	R: fxd, comp, 4.7K ±10%, 1/2 W	
R11	0693-1021	R: fxd, comp, 1K ±10%, 2 W	
R12	0687-5621	R: fxd, comp, 5.6K ±10%, 1/2 W	
R13	0687-1221	R: fxd, comp, 1.2K ±10%, 1/2 W	
R14	0687-1531	R: fxd, comp, 15K ±10%, 1/2 W	
R15	0687-6831	R: fxd, comp, 68K ±10%, 1/2 W	
R16	0687-6821	R: fxd, comp, 6.8K ±10%, 1/2 W	
R17	0727-0103	R: fxd, mfgl, 1.08K ±1%, 1/2 W	
R18	403B-26A	R: fxd, WW, 3.41K ±0.2%, 1/2 W	
R19	403B-26B	R: fxd, WW, 1.081K ±0.2%, 1/2 W	
R20	0727-0084	R: fxd, mfgl, 634 ohms ±1%, 1/2 W	
R21	403B-26C	R: fxd, WW, 341.9 ohms ±0.2%, 1/2 W	
R22	0727-0096	R: fxd, mfgl, 920 ohms ±1%, 1/2 W	
R23	403B-26D	R: fxd, WW, 158.1 ohms ±0.2%, 1/2 W	
R24	0758-0074	R: fxd, mfgl, 27K ±5%, 1/2 W	
R25	0758-0076	R: fxd, mfgl, 68K ±5%, 1/2 W	
R26	0758-0073	R: fxd, mfgl, 24K ±5%, 1/2 W	
R27	0687-1031	R: fxd, comp, 10K ±10%, 1/2 W	
R28	0727-0017	R: fxd, mfgl, 37.35 ohm ±1/2%, 1/2 W	
R29	2100-0240	R: var, WW, 50 ohms ±20%, 1 W	
R30	0727-0050	R: fxd, mfgl, 180 ohms ±1%, 1/2 W	
R31	403A-26G	R: fxd, WW, 2 sect, 30 ohms	
R32		Same as R27	
R33	2100-0154	R: var, comp, 1K ±30%, 3/10 W	
R34	0758-0048	R: fxd, mfgl, 8.2K ±5%, 1/2 W	
R35	0687-3911	R: fxd, comp, 390 ohms ±10%, 1/2 W	
R36		Same as R27	
R37	0686-3015	R: fxd, comp, 300 ohms ±5%, 1/2 W	
R38	0687-3331	R: fxd, comp, 33K ±10%, 1/2 W	
R39	2100-0391	R: var, WW, 1K ±20%, 1.25 W	
R40		Same as R12	
R41		Same as R38	
R42	0687-2211	R: fxd, comp, 220 ohm ±10%, 1/2 W	
R43	0687-3921	R: fxd, comp, 3.9K ±10%, 1/2 W	
R44	0687-2241	R: fxd, comp, 220K ±10%, 1/2 W	
R45	2100-0144	R: var, comp, 250K ±30%, 0.2 W	
R46		Same as R10	
R47	0758-0007	R: fxd, mfgl, 150 ohm ±5%, 1/2 W	
S1	403B-19W	Assy, RANGE switch, 3 sect, 12 pos., includes: C2 thru C6	
S2	403B-19A	Assy, FUNCTION Switch, 2 sect, 3 pos., includes: R42 and R43	
	7123-0101	Washer, fluorescent indicator for use with Function Switch Knob	
S3	3101-0033	Switch - Slide: DPDT 115-230V	

\# See introduction to this section

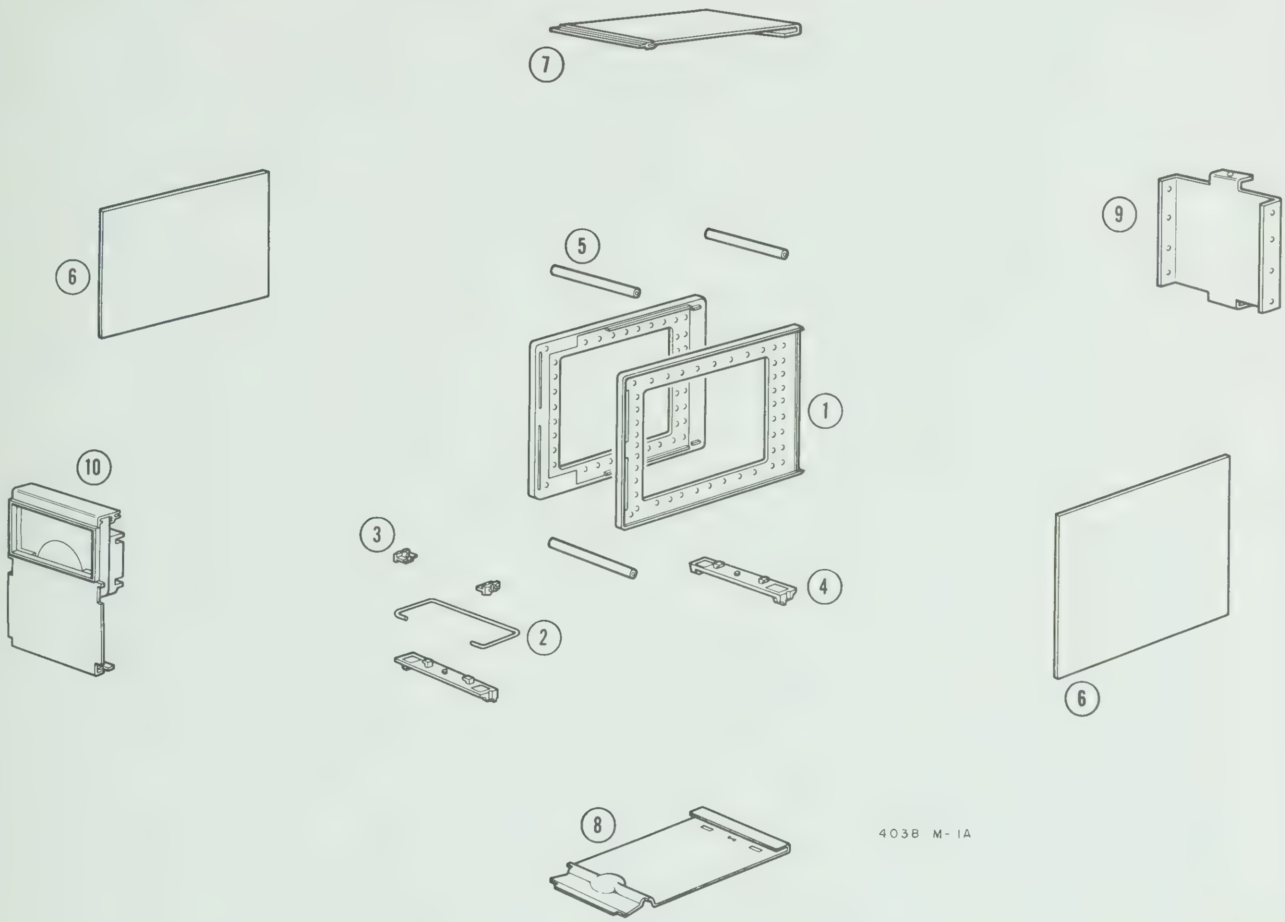
Table 6-1. Index by Reference Designator (cont'd)

Circuit Reference	ⓗⓟ Stock No.	Description	Note
T1	9100-0172	Transformer	
W1	8120-0078	Assy, cable, power	
XF1	1400-0008	Holder Fuse, 1/2" wide, 3/16" thick, 1-5/8" long	
		MISCELLANEOUS	
	403B-902	Operating & Service Manual	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Cabinet Parts



Item Number	ⓗ Stock No.	Description	Note
1	5060-0702	Frame Assembly	
2	1490-0031	Stand: Tilt	
3	5040-0700	Hinge	
4	5060-0727	Foot Assembly	
5	5020-0700	Spacer	
6	5000-0702	Cover: Side	
7	5060-0705	Cover Assembly: Top	
8	5000-0710	Cover Assembly: Bottom	
9	403B-2B	Panel: Rear	
10	403B-2A	Panel: Front	

Table 6-1. Index by Reference Designator

No. on Illustration on Figure 6-1	Name/Designator	Stock Number
1	Indicator, Neon	See DS1, table 6-1
2	Retainer clip	0510-0123
3	Insulation, vinyl tubing (specify 1" length)	0890-0057
4	Knob, bar w/indicator, black	0370-0087
5	Special washer 3/8 inch OD x 0.26 inch ID	3050-0014
6	Water, fluorescent indicator for use with Function Switch Knob	7123-0101
7	Panel, front	403B-2A
8	Meter, 0-100 μa dc (403B)	See M1, table 6-1
	or	
	Meter, 0-100 μa dc, DB Scale (403B-db)	
9	3/8" - 32 x 1/2" nut, hex.	2950-0001
10	AC shield	403B-6D
11	Vertical shield	403B-6A
12	Bushing, threaded 3/8 - 32	1410-0003
13	6.32 x 5/16" nut, hex. w/lock	2420-0001
14	Assy, FUNCTION Switch: 2 sect, 3 pos	See S2, table 6-1
15	Screw 6-32 x 3/8 flat head phillips drive	2370-0013
16	Screw 6-32 x 3/8 flat head slot drive	2370-0002
17	Cover 1/3 module 8 inch deep, top	5060-0705
18	Assy, printed circuit	See A1, table 6-1
19	Screw 6-32 x 1/2 binding head with lock	2390-0001
20	Battery holder	403B-64A
21	Screw 6-32 x 3/8 pan head	2390-0010
22	Battery holder	403B-64B
23	Rear panel, 1/3 module, 1/2 recess	403B-2B
24	Side frame 6 x 8 sub-module	5060-0702
25	Switch shield	403B-6B
26	Side cover, 6 x 8, SM	5000-0702
27	Same as 15	
28	Bottom cover 1/3 module, 8 inch DP	5000-0710
29	Assy, RANGE Switch: 3 sect, 12 pos	See S1, table 6-1
30	Same as 15	
31	6.32 x 5/16" nut	2420-0002
32	#6 split lock, SS	2190-0006
33	Same as 16	
34	Spacer no. 6 x 5/16	0380-0007
35	3/8" ID x 5/8" OD flat washer	3050-0067
36	#6 internal lock washer	2190-0007
37	3/8" internal lock (heavy) washer	2190-0022
38	#6 solder lug "L"	0360-0042
39	Tinnerman retainers	0590-0039
40	Same as 9	
41	Same as 13	
42	Coupler, shaft 1/4"	5020-0237
43	#10 solder lug	0360-0007
44	Same as 43	
45	#10 internal-external lock washer	2190-0028
46	#10 internal lock washer	2190-0011
47	Insulator B.P. double without locating key	0340-0086
48	Hinge	5040-0700
49	Stand, third mod. tilt	1490-0031
50	Foot assy, third mod.	5060-0727
51	Assy, dial	403B-99
52	Insulator, binding post: dbl keyed	0340-0090
53	Spacer binding post	1410-0091
54	Assy, binding post: black w/strap	See J1, table 6-1
	Assy, binding post: red	
	Assy, binding post: black	
55	Meter trim, third mod.	5020-0704
56	Battery, nickel cadmium, 6.5 V nom. 225 mah	See BT1, 2, 3, 4, table 6-1
57	Assy, resistor board	See A3, table 6-1

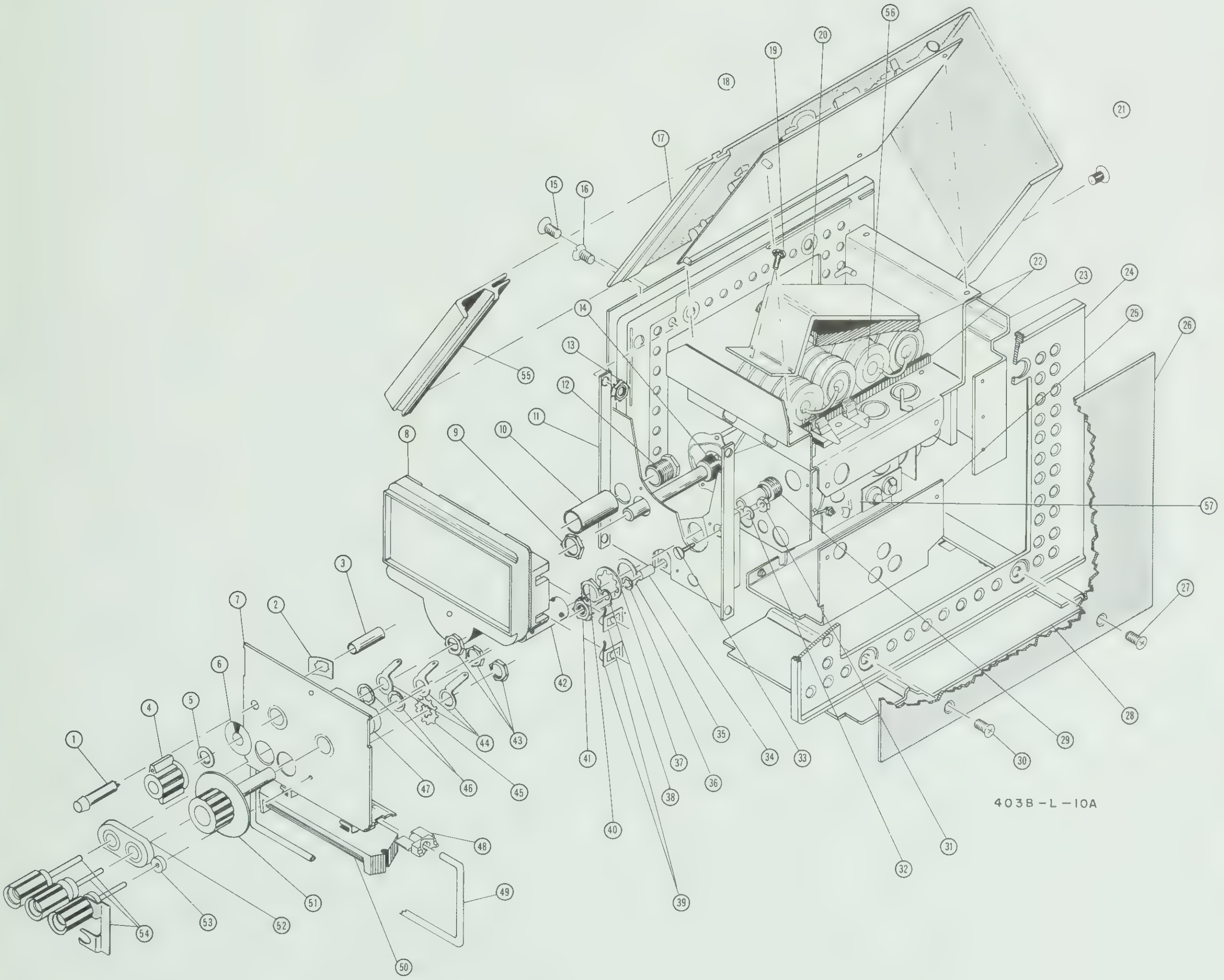


Figure 6-1. Exploded View

Table 6-2. Replaceable Parts

Stock No.	Description	Mfr.	Mfr. Part No.	TQ	RS	
403A-26G	R: fxd, WW, 2 sect, 30 ohms	28480	403A-26G	1		
403B-19A	Assy, FUNCTION Switch: 2 sect, 3 pos, includes, R42 and R43	28480	403B-19A	1		
403B-19W	Assy, RANGE Switch: 3 sect, 12 pos, includes, C2 thru C6	28480	403B-19W	1		
403B-26A	R: fxd, WW, 341K ±0.2%, 1/2 W	28480	403B-26A	1		
403B-26B	R: fxd, WW, 1.081K ±2%, 1/2 W	28480	403B-26B	1		
403B-26C	R: fxd, WW, 341.9 ohms ±0.2%, 1/2 W	28480	403B-26C	1		
403B-26D	R: fxd, WW, 158.1 ohms ±0.2%, 1/2 W	28480	403B-26D	1		
403B-65A	Assy, printed circuit, includes, C7 thru C20 Q1 thru Q6, etc.	28480	403B-65A	1		
403B-65B	Assy, resistor board, includes, C21 R37 thru R39, etc.	28480	403B-65B	1		
403B-65C	Assy, resistor board, includes, C2 thru C5 R1 thru R5	28480	403B-65C	1		
403B-902	Operating and Service Manual	28480	403B-902	1		
0130-0003	C: var, cer, 1.5-7 pf ±10%, 500 vdcw	72982	503-000-COPO-10R	2		
0130-0017	C: var, cer, 8-50 pf, 500 vdcw	72982	557-019-U2 P034R	1		
0140-0145	C: fxd, mica, 22 pf ±5%, 500 vdcw	04062	DM15C220J	1		
0140-0151	C: fxd, mica, 820 pf ±2%, 300 vdcw	04062	DM15F821G	1		
0140-0178	C: fxd, mica, 560 pf ±2%, 300 vdcw	04062	DM15F561G	1		
0140-0216	C: fxd, mica, 120 pf ±2%, 300 vdcw	04062	DM15F161G	1		
0160-0205	C: fxd, mica, 10 pf ±5%, 500 vdcw	04062	DM15C100J	1		
0170-0033	C: fxd, 0.18 μf ±10%, 600 vdcw	09134	Type 27	1		
0180-0008	C: fxd, elect., 4.0 μf -15% +20%, 60 vdcw	21520	PP4B60A2	1		
0180-0033	C: fxd, elect., 50 μf, 6 vdcw	56289	30D133A1	1		
0180-0039	C: fxd, elect., 100 μf, 12 vdcw	56289	30D154A1	1		
0180-0058	C: fxd, elect., 50 μf, -10% +100%, 25 vdcw	56289	30D186A1	1		
0180-0059	C: fxd, elect., 10 μf, -10% +100%	56289	30D182A1	1		
0180-0060	C: fxd, elect., 200 μf -10% +100%, 3 vdcw	56289	30D116A1	1		
0180-0063	C: fxd, elect., 500 μf -10% +100%, 3 vdcw	56289	30D120A1	1		
0180-0064	C: fxd, elect., 35 μf -10% +100%, 6 vdcw	56289	30D132A1	1		
0180-0104	C: fxd, elect., 200 μf, 15 vdcw	56289	30D174A1	1		
0180-0149	C: fxd, elect., 65 μf, 60 vdcw	56289	Type 30D	1		
0180-0150	C: fxd, elect., 1200 μf, 10 vdcw	56289	Type 34D	1		
0340-0090	Insulator, binding post: dbl keyed	28480	0340-0090	1		
0686-3015	R: fxd, comp, 300 ohms, ±5%, 1/2 W	01121	EB3015	1		
0687-1031	R: fxd, comp, 10K ±10%, 1/2 W	01121	EB1031	3		
0687-1221	R: fxd, comp, 1.2K ±10%, 1/2 W	01121	EB1221	1		
0687-1531	R: fxd, comp, 15K ±10%, 1/2 W	01121	EB1531	1		
0687-1541	R: fxd, comp, 150K ±10%, 1/2 W	01121	EB1541	1		
0687-2211	R: fxd, comp, 220 ohm ±10%, 1/2 W	01121	EB2211	1		
0687-2241	R: fxd, comp, 220K ±10%, 1/2 W	01121	EB2241	1		
0687-3331	R: fxd, comp, 33K ±10%, 1/2 W	01121	EB3331	2		
0687-3911	R: fxd, comp, 390 ohms ±10%, 1/2 W	01121	EB3911	1		
0687-3921	R: fxd, comp, 3.9K ±10%, 1/2 W	01121	EB3921	1		
0687-4721	R: fxd, comp, 4.7K ±10%, 1/2 W	01121	EB4721	2		
0687-4751	R: fxd, comp, 4.7M ±10%, 1/2 W	01121	EB3951	1		
0687-5621	R: fxd, comp, 5.6K ±10%, 1/2 W	01121	EB5621	2		
0687-6821	R: fxd, comp, 6.8K ±10%, 1/2 W	01121	EB6821	1		
0687-6831	R: fxd, comp, 68K ±10%, 1/2 W	01121	EB6831	1		

See introduction to this section

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

CODE NO.	MANUFACTURER	ADDRESS
00136	McCoy Electronics	Mount Holly Springs, Pa.
00334	Humidial Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.
00853	Sangamo Electric Company, Ordill Division (Capacitors)	Marion, Ill.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	Pacific Semiconductors, Inc.	Culver City, Calif.
01295	Texas Instruments, Inc. Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01930	Amerock Corp.	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.	Morristown, N.J.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04298	Elgin National Watch Co., Electronics Division	Burbank, Calif.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Prods., Inc. Electronic Tube Div.	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc. Western Division	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04796	Sequoia Wire & Cable Company	Redwood City, Calif.
04870	P. M. Motor Co.	Chicago 44, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.
05624	Barber Colman Co.	Rockford, Ill.
05729	Metropolitan Telecommunications Corp., Metro Cap. Div.	Brooklyn, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
06004	The Bassick Co.	Bridgeport, Conn.
06136	Ward Leonard Electric	Los Angeles, Calif.
06175	Bausch and Lomb Optical Co.	Rochester, N.Y.
06402	E.T.A. Products Co. of America	Chicago, Ill.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06751	U.S. Semcor Div. of Nuclear Corp. of Am.	Phoenix, Ariz.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07700	Technical Wire Products	Springfield, N.J.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07966	Shockley Semi-Conductor Laboratories	Palo Alto, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada
08717	Sloan Company	Burbank, Calif.
08718	Cannon Electric Co. Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S. Inc.	Lowell, Mass.
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays, Inc.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11312	Microwave Electronics Corp.	Palo Alto, Calif.
11534	Duncan Electronics, Inc.	Santa Ana, Calif.
11711	General Instrument Corporation Semiconductor Division	Newark, N.J.
11717	Imperial Electronics, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12697	Clarostat Mfg. Co.	Dover, N.H.
12859	Nippon Electric Co., Ltd.	Tokyo, Japan
12930	Delta Semiconductor Inc.	Newport Beach, Calif.
13396	Telefunken (G.M.B.H.)	Hannover, Germany
14099	Sem-Tech	Newbury Park, Calif.
14193	Calif. Resistor Corp.	Santa Monica, Calif.
14298	American Components, Inc.	Conshohocken, Pa.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
15909	The Daven Co.	Livingston, N.J.
16688	De Jur-Amsco Corporation	Long Island City 1, N.Y.
16758	Delco Radio Div. of G. M. Corp.	Kokomo, Ind.
18873	E. I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21226	Executive, Inc.	New York, N.Y.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G.E., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26365	Gries Reproducer Corp.	New Rochelle, N.Y.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
37942	P. R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C. A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Company	Lexington, Mass.
52090	Rowan Controller Co.	Baltimore, Md.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
60741	Tripplett Electrical Inc.	Bluffton, Ohio
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Swissvale, Pa.
62119	Universal Electric Co.	Owosso, Mich.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
66295	Wittek Manufacturing Co.	Chicago 23, Ill.
66346	Wollensak Optical Co.	Rochester, N.Y.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	New York, N.Y.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio Inc.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp.	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71450	CTS Corp.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C. P. Clare & Co.	Chicago, Ill.
71528	Standard-Thomson Corp., Clifford Mfg. Co. Div.	Waltham, Mass.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A. O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72092	Eitel-McCullough, Inc.	San Bruno, Calif.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
71707	Coto Coil Co., Inc.	Providence, R.I.
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72964	Robert M. Hadley Co.	Los Angeles, Calif.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	Hamden, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.

00015-32
Revised: July 26, 1963

From: F.S.C. Handbook Supplements
H4-1 Dated Supplement 22
H4-2 Dated April 1962

Table 6-2. Replaceable Parts (cont'd)

ⓗⓟ Stock No.	Description	Mfr.	Mfr. Part No.	TQ	RS	
0693-1021	R: fxd, comp, 1K ±10%, 2 W	01121	HB1021	1		
0727-0017	R: fxd, mfgl, 37.35 ohm ±1/2%, 1/2 W	19701	DC1/2CR5	1		
0727-0050	R: fxd, mfgl, 180 ohms ±1%, 1/2 W	19701	DC1/2CR5	1		
0727-0056	R: fxd, mfgl, 216 ohms ±1/2%, 1/2 W	19701	DC1/2AR5	1		
0727-0084	R: fxd, mfgl, 634 ohms ±1%, 1/2 W	19701	DC1/2CR5	1		
0727-0096	R: fxd, mfgl, 920 ohms ±1%, 1/2 W	19701	DC1/2CR5	1		
0727-0103	R: fxd, mfgl, 1.08K ±1%, 1/2 W	19701	DC1/2CR5	1		
0727-0287	R: fxd, comp, 2 Meg ±1%, 1/2 W	19701	DC1/2CR5	1		
0727-0443	R: fxd, comp, 19.1K ±1%, 1/2 W	19701	DC1/2CR5	1		
0758-0007	R: fxd, mfgl, 150 ohms ±5%, 1/2 W	07115	C20	1		
0758-0022	R: fxd, comp, 82K ±5%, 1/2 W	07115	C20	1		
0758-0048	R: fxd, mfgl, 8.2K ±5%, 1/2 W	07115	C20	1		
0758-0051	R: fxd, comp, 43K ±5%, 1/2 W	07115	C20	1		
0758-0073	R: fxd, mfgl, 24K ±5%, 1/2 W	07115	C20	1		
0758-0074	R: fxd, mfgl, 27K ±5%, 1/2 W	07115	C20	1		
0758-0076	R: fxd, mfgl, 68K ±5%, 1/2 W	07115	C20	1		
1120-0315	Meter, 0-100 μa dc (403B)	28480	5060-3862 5060-3864 (vendor choice)	1		
1120-0316	Meter, 0-100 μa dc, DB Scale (403B-db)	28480	5060-3863 5060-3865 (vendor choice)	1		
1251-0148	Connector: power, 3 pin male	0000U	H-1061 1G-3L	1		
1400-0008	Holder Fuse, 1/2" wide, 3/16" thick, 1-5/8" long	75915	3510-11	1		
1420-0015	Battery, Nickel Cadmium, 6.5 V nom. 225 mah	88220	6.0V/255B	4		
1450-0048	Indicator, Neon	08717	858R	1		
1510-0008	Assy, Binding Post: red	28480	1510-0008	1		
1510-0009	Assy, Binding Post: black	28480	1510-0009	1		
1850-0060	Transistor, PNP	02735	3748	1		
1850-0064	Transistor, PNP, 2N1183	02735	2N1183	1		
1850-0096	Transistor, PNP, 2N2189	01295	2N2189	3		
1854-0017	Transistor, NPN, 2N706A	03508	2N706A	2		
1901-0025	Diode, Si, 50 ma, 100 piv	07910	CD1598	5		
1901-0027	Diode, Si, HD5004	73293	HD5004	2		
1901-0044	Diode, Si	28480	1901-0103	1		
1902-0108	Diode, Breakdown	28480	1902-0108	2		
2100-0144	R: var, comp, 250K ±30%, 2 W	11237	UPE70	1		
2100-0154	R: var, comp, 1K ±30%, 3/10 W	11237	UPE70	1		
2100-0240	R: var, WW, 50 ohms ±20%, 1 W	11236	Series 110	1		
2100-0390	R: var, comp, duel, 2K and 6K ohms, 1-1/4 W	71590	Series 5 Type 73-2	1		
2100-0391	R: var, WW, 1K ±20%, 1/25 W	11236	Series 110	1		
2110-0011	Fuse, 1/16 amp, 250 V maximum, 5.4 ohm	75915	#312-062	1		
3101-0033	Switch - Slide: DPDT 115-230 V	42190	4633	1		
5060-0626	Assy, binding post: black w/strap	28480	5060-0626	1		
7123-0101	Washer, fluorescent indicator for use with Function Switch Knob	91345	-----	1		
8120-0078	Cord, Power	70903	KH4147	1		
9100-0172	Transformer	98734	6-2249	1		

See introduction to this section

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

CODE NO.	MANUFACTURER	ADDRESS
73734	Federal Screw Products Co.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74455	J. H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E. F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littelfuse Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C. W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J. W. Miller Co.	Los Angeles, Calif.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	Bendix Pacific Division of Bendix Corp.	No. Hollywood, Calif.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	Potter and Brumfield, Div. of American Machine and Foundry	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78283	Signal Indicator Corp.	New York, N.Y.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	Pasadena, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80120	Schnitzer Alloy Products	Elizabeth, N.J.
80130	Times Facsimile Corp.	New York, N.Y.
80131	Electronic Industries Association Any brand tube meeting EIA standards	Washington, D.C.
80207	Unimax Switch, Div. of W. L. Maxson Corp.	Wallingford, Conn.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Laboratories, Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Fulton Controls Co.	Columbus 16, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81073	Grayhill Co.	LaGrange, Ill.
81312	Winchester Electronics Co., Inc.	Norwalk, Conn.
81349	Military Specification	
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Components Div., Industr. Tube Operations	Newton, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Allen B. DuMont Labs., Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc., Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls, Inc., Div. of Texas Instruments, Inc., Spencer Prods.	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Manufacturing Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83053	Western Washer Mfr. Co.	Los Angeles, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	Pyramid Electric Co.	Darlington, S.C.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Union, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics, Inc.	New York, N.Y.
84396	A. J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85471	A. B. Boyd Co.	San Francisco, Calif.
85474	R. M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86197	Clifton Precision Products	Clifton Heights, Pa.
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87216	Philco Corp. (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
87664	Van Waters & Rogers Inc.	Seattle, Wash.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
89636	Carter Parts Div. of Economy Baler Co.	Chicago, Ill.
89665	United Transformer Co.	Chicago, Ill.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91345	Miller Dial & Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers, Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91929	Minneapolis-Honeywell Regulator Co., Microswitch Div.	Freeport, Ill.
92196	Universal Metal Products, Inc.	Bassett Puente, Calif.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94144	Raytheon Mfg. Co., Industrial Components Div., Receiving Tube Operation	Quincy, Mass.
94145	Raytheon Mfg. Co., Semiconductor Div., California Street Plant	Newton, Mass.
94148	Scientific Radio Products, Inc.	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	East Paterson, N.J.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95264	Lerco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95348	Gordas Corp.	Bloomfield, N.J.
95354	Methode Mfg. Co.	Chicago, Ill.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96256	Thordarson-Meissner Div. of Maguire Industries, Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
97979	Reon Resistor Corp.	Yonkers, N.Y.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98734	Palo Alto Engineering Co., Inc.	Palo Alto, Calif.
98821	North Hills Electric Co.	Mineola, N.Y.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Ill.
99957	Technology Instrument Corp. of Calif.	Newbury Park, Calif.

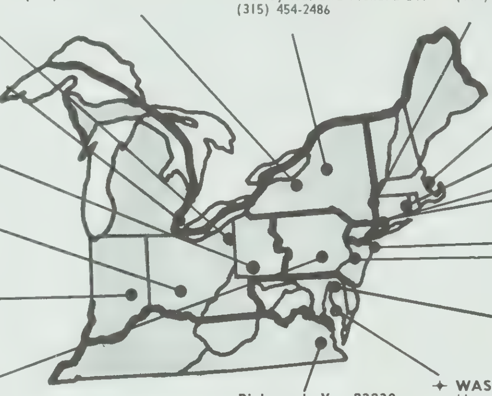
THE FOLLOWING H-P VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

CODE NO.	MANUFACTURER	ADDRESS
0000F	Malco Tool and Die	Los Angeles, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000N	Nahm-Bros. Spring Co.	San Leandro, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
0000T	Texas Instruments, Inc. Metals and Controls Div.	Versailles, Ky.
0000U	Tower Mfg. Corp.	Providence, R.I.
0000W	Webster Electronics Co. Inc.	New York, N.Y.
0000X	Spruce Pine Mica Co.	Spruce Pine, N.C.
0000Y	Midland Mfg. Co. Inc.	Kansas City, Kans.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AA	British Radio Electronics Ltd.	Washington, D.C.
000AB	ETA	England
000AC	Indiana General Corp., Elect. Div.	Indiana
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000CC	Computer Diode Corp.	Lodi, N.J.
000EE	A. Williams Manufacturing Co.	San Jose, Calif.
000GG	Goshen Die Cutting Service	Goshen, Ind.
000HH	Rubbercraft Corp.	Torrance, Calif.
000II	Birtcher Corporation, Industrial Division	Monterey Park, Calif.
000KK	Amatom	New Rochelle, N.Y.
000LL	Avery Label	Monrovia, Calif.
000MM	Rubber Eng. & Development	Hayward, Calif.
000NN	A "N" D Manufacturing Co.	San Jose 27, Calif.
000PP	Atohm Electronics,	Sun Valley, Calif.
000QQ	Cooltron	Oakland, Calif.
000RR	Radio Industries	Des Plaines, Ill.
000SS	Control of Elgin Watch Co.	Burbank, Calif.
000TT	Thomas & Betts Co., The	Elizabeth 1, N.J.
000WW	California Eastern Lab.	Burlingame, Calif.
000XX	Methode Electronics, Inc.	Chicago 31, Ill.
000YY	S. K. Smith Co.	Los Angeles 45, Calif.

From: F.S.C. Handbook Supplements
H4-1 Dated Supplement 22
H4-2 Dated April 1962

00015-32
Revised: July 26, 1963

HEWLETT-PACKARD SALES AND SERVICE OFFICES IN NORTH AMERICA



✦ **Cleveland, Ohio 44129**
Crossley Associates, Inc.
5579 Pearl Road
(216) 884-9209

✦ **Detroit, Mich. 48235**
Crossley Associates, Inc.
14425 West Eight Mile Road
(313) 342-5700

✦ **PITTSBURGH AREA**
Crossley Associates, Inc.
2545 Moss Side Blvd.
Monroeville, Pa. 15146
(412) 271-5227

✦ **Dayton, Ohio 45409**
Crossley Associates, Inc.
1250 W. Dorothy Lane
(513) 299-3594

✦ **Indianapolis, Ind. 46205**
Crossley Associates, Inc.
3919 Meadows Dr.
(317) 546-4891

Camp Hill, Pa.
Robinson Sales Division
Hewlett-Packard Company
(717) 737-6791

✦ **Rochester, N. Y. 14625**
Hewlett-Packard Company
800 Linden Avenue
(716) 381-4120

✦ **Syracuse, N. Y. 13211**
Hewlett-Packard Company
Pickard Building
Molloy Rd. and Pickard Dr.
(315) 454-2486

✦ **Poughkeepsie, N. Y. 12601**
Hewlett-Packard Company
82 Washington St.
(914) 454-7330

✦ **BOSTON AREA**
Yewell Associates, Inc.
Middlesex Turnpike
Burlington, Mass. 01804
(617) 272-9000

✦ **Middletown, Conn. 06458**
Yewell Associates, Inc.
589 Saybrook Rd.
(203) 346-6611

✦ **New York, N. Y. 10021**
RMC Sales Division
Hewlett-Packard Company
236 East 75th Street
(212) 879-2023

Englewood, N. J. 07631
RMC Sales Division
Hewlett-Packard Company
391 Grand Avenue
(201) 567-3933

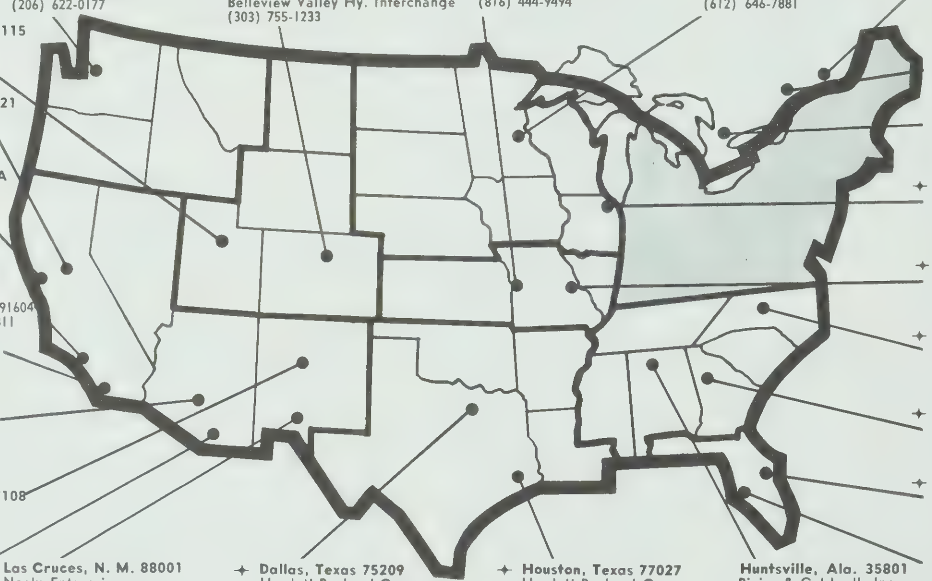
ASBURY PARK AREA
Robinson Sales Division
Hewlett-Packard Company
Shrewsbury, New Jersey
(201) 747-1060

✦ **PHILADELPHIA AREA**
Robinson Sales Division
Hewlett-Packard Company
144 Elizabeth Street
West Conshohocken, Pa. 19428
(215) 248-1600 and 828-6200

Baltimore, Md. 21215
Horman Associates, Inc.
3006 West Cold Spring Lane
(301) 664-4400

Richmond, Va. 23230
Bivins & Caldwell, Inc.
2112 Spencer Road
(703) 282-5451

✦ **WASHINGTON, D. C. AREA**
Horman Associates, Inc.
941 Rollins Avenue
Rockville, Md. 20852
(301) 427-7560



✦ **Seattle, Wash. 98109**
ARVA, Inc.
1320 Prospect Street
(206) 622-0177

✦ **Denver, Colo. 80222**
Lahana & Company
P.O. Box 22065
Belleview Valley Hy. Interchange
(303) 755-1233

Kansas City, Mo. 64131
Harris-Hanson Company
7916 Paseo Street
(816) 444-9494

✦ **St. Paul, Minn. 55114**
Crossley Associates, Inc.
842 Raymond Avenue
(612) 646-7881

✦ **Montreal, Quebec**
Hewlett-Packard (Canada) Ltd.
8270 Mayrand Street
(514) 735-2273

Ottawa, Ontario
Hewlett-Packard (Canada) Ltd.
1762 Carling Avenue
(613) 722-8162

Toronto, Ontario
Hewlett-Packard (Canada) Ltd.
1415 Lawrence Avenue W.
(416) 249-9196

Salt Lake City, Utah 84115
Lahana & Co.
1482 Major St.
(801) 486-8166

✦ **Sacramento, Calif. 95821**
Neely Enterprises
2591 Carlsbad Ave.
(916) 482-1463

△ **SAN FRANCISCO AREA**
Neely Enterprises
501 Laurel Street
San Carlos, Calif. 94071
(415) 591-7661

✦ **LOS ANGELES AREA**
Neely Enterprises
3939 Lankershim Blvd.
North Hollywood, Calif. 91604
(213) 877-1282 and 766-3811

✦ **San Diego, Calif. 92106**
Neely Enterprises
1055 Shafter Street
(714) 223-8103

✦ **Scottsdale, Ariz. 85251**
Neely Enterprises
3009 No. Scottsdale Rd.
(602) 945-7601

✦ **Albuquerque, N. M. 87108**
Neely Enterprises
6501 Lomas Blvd., N. E.
(505) 255-5586

Tucson, Ariz. 85716
Neely Enterprises
232 So. Tucson Blvd.
(602) 623-2564

Las Cruces, N. M. 88001
Neely Enterprises
114 S. Water Street
(505) 526-2486

✦ **Dallas, Texas 75209**
Hewlett-Packard Co.
P.O. Box 7166
3605 Inwood Road
(214) 357-1881 and 332-6667

✦ **Houston, Texas 77027**
Hewlett-Packard Co.
P.O. Box 22813
4242 Richmond Ave.
(713) 667-2407

Huntsville, Ala. 35801
Bivins & Caldwell, Inc.
Holiday Office Center
Suite No. 9
(205) 881-4591

✦ **Chicago, Ill. 60645**
Crossley Associates, Inc.
2501 West Peterson Ave.
(312) 275-1600

✦ **St. Louis, Mo. 63144**
Harris-Hanson Company
2814 South Brentwood Blvd.
(314) 647-4350

✦ **High Point, N. C. 27262**
Bivins & Caldwell, Inc.
1923 N. Main Street
(919) 882-6873

✦ **Atlanta, Ga. 30305**
Bivins & Caldwell, Inc.
3110 Maple Drive, N. E.
(404) 233-1141

✦ **Orlando, Fla. 32803**
Stiles Sales Division
Hewlett-Packard Company
621 Commonwealth Ave.
(305) 425-5541

St. Petersburg, Fla. 33708
Stiles Sales Division
Hewlett-Packard Company
410-150th Ave., Madeira Beach
(813) 391-0211

△ For replacement parts and repair services in the San Francisco area, please contact Hewlett-Packard Company, 395 Page Mill Road, Palo Alto, California, Tel: (415) 326-3950.

✦ Indicates Instrument Repair Stations.

HEWLETT-PACKARD COMPANY
1501 Page Mill Road • Palo Alto, California 94304
Tel: (415) 326-7000 • TWX: 415-492-9200 • Cable: HEWPACK

DYMEC DIVISION
395 Page Mill Road • Palo Alto, California 94306
Tel: (415) 326-1755 • TWX: 415-492-9363

BOONTON RADIO COMPANY
Green Pond Road • Rockaway, New Jersey 07866
Tel: (201) 627-6400 • Cable: BOONRACO

HARRISON LABORATORIES
41 Industrial Road • Berkeley Heights, N. J. 07922
Tel: (201) 464-1234 • TWX: Summit, N. J.

SANBORN COMPANY
175 Wyman St., Waltham, Mass. 02154
Tel: (617) 894-6300 • TWX: 617-894-0789

F. L. MOSELEY CO.
409 N. Fair Oaks Ave. • Pasadena, Calif. 91102 • Tel: (213) 681-0208 • TWX: PASA CAL 7687 • Cable: MOCOPAS

MARCH 64

AUTHORIZED SALES AND SERVICE OFFICES IN WESTERN EUROPE

HEWLETT-PACKARD S.A.
54 Route des Acacias
Geneva, Switzerland
Telephone: (022) 42.81.50
Telex: 2.24.86
Cable: HEWPACKSA

Sweden
✦ H-P Instrument AB
Centralvagen 28
Solna Centrum
Tel: 08-83.08.30

Norway
Morgenstierne & Co.
✦ Wessels Gate 6, Oslo
Tel: 42.99.93

Netherlands
Hewlett-Packard Benelux
✦ 23, Burg. Roellstraat, Amsterdam W
Tel: 13 28 98 and 13 54 99

United Kingdom
Hewlett-Packard Ltd.
✦ Dallas Road
Bedford, England
Tel: Bedford 68052

Belgium
Hewlett-Packard Benelux
✦ 20-24 Rue de l'Hopital, Brussels I
Tel: 11.22.20

France
Hewlett-Packard (France)
✦ Boulevard Massena 150
Paris 13e
Tel: 707.97.19

Portugal
TELECTRA
Rua Rodrigo da Fonseca 103
P.O. Box 2531
Lisbon I
Tel: 68 60 72
68 60 73
68 60 74

Finland
INTO O/Y
P.O. Box 153
✦ 11 Meritullinkatu, Helsinki
Tel: 66.39.09 and 35.125

Denmark
Tage Olsen A/S
✦ Centrumgården, Room 133
6D, Vesterbrogade, Copenhagen V.
Tel: Minerva 6838

Germany
Hewlett-Packard V.m.b.H.

Steindamm 35, Hamburg
Tel: 24-05-51

✦ Kurhessenstrasse 95
6 Frankfurt am Main
Tel: 52.00.36

Reginfriedstrasse 13
8 Munich 9
Tel: 49.51.21

Austria
Hewlett-Packard S.A.
Geneva

Yugoslavia
Belram Electronics
83 Av. des Mimosas
Brussels 15, Belgium
Tel: 35.29.58

Turkey
TELEKOM Engineering Bureau
P.O. Box 376 — Galata
Istanbul
Tel: 49.40.40

Spain
ATAIO, Ingenieros
A. Aguilera, No. 8, Madrid 15
Tel: 223.27.42
223.41.71 and 224.84.97

Italy
Dott. Ing. Mario Vianello
✦ Via L. Anelli 13, Milan
Tel: 553-081 and 553-811

Via S. Croce in Gerusalemme 97, Rome
Tel: 7.567.250 & 7.567.941

Switzerland
Max Paul Frey
✦ Wankdorffeldstrasse 66, Bern
Tel: (031) 42.00.78

Greece
K. Karayannis
Klaftmonos Square, Athens 124
Tel: 230.301 (5 Lines)

Authorized Sales and Service Offices in Other Areas

Argentina
Mauricio A. Suarez
Telecomunicaciones
Carlos Calvo 224, Buenos Aires
Tel: 30-6312

Australia
Sample Electronics Pty. Ltd.

✦ 9-11 Cremorne Street
Richmond E. 1, Victoria
Tel: 42-4757 (3 lines)

48 Chippen Street, Sydney
New South Wales
Tel: 69-6338 (6 lines)

FOR SALES AND SERVICE ASSISTANCE IN AREAS NOT LISTED CONTACT:

International Marketing Department
Hewlett-Packard Company
✦ 1501 Page Mill Road
Palo Alto, California 94304, U.S.A.
Telephone: (415) 326-7000
TWX: 415-492-9200
Telex: 033811
Cable: HEWPACK

India
The Scientific Instrument Company, Ld.

6, Tej Bahadur Sapru Road, Allahabad I
Tel: 2451

240, Dr. Dadabhai Naoroji Road,
Bombay I
Tel: 26-2642

11, Esplanade East, Calcutta I
Tel: 23-4129

30, Mount Road, Madras 2
Tel: 86339

B-7, Ajmeri Gate Extn., New Delhi I
Tel: 271053

Iran
Telecom Ltd.
P.O. Box 1812, Tehran
Tel: 43850, 48111

Israel
Electronics & Engineering Ltd.
✦ 16 Kremenetski St., Tel Aviv
Tel: 35021 (3 lines)

Japan
✦ Yokogawa-Hewlett-Packard, Ltd.
2-9, Nakacho, Musashino-shi, Tokyo
Tel: Ogikubo (391) 1901
Musashino (0422)-2 3701

Korea
American Trading Company, Korea, Ltd.
Song Bo Building
112-35 Sokong-Dong, Seóul
Seóul P.O. Box 1103
Seóul
Tel: 3-7049, 3-7613

New Zealand
Sample Electronics (N. Z.) Ltd.
8 Matipo Street
Onehunga S. E. 5, Auckland
Tel: 565-361

Puerto Rico & Virgin Islands
San Juan Electronics, Inc.
P.O. Box 5167
Pta. de Tierra Sta., San Juan
Tel: 722-3342, 724-4406

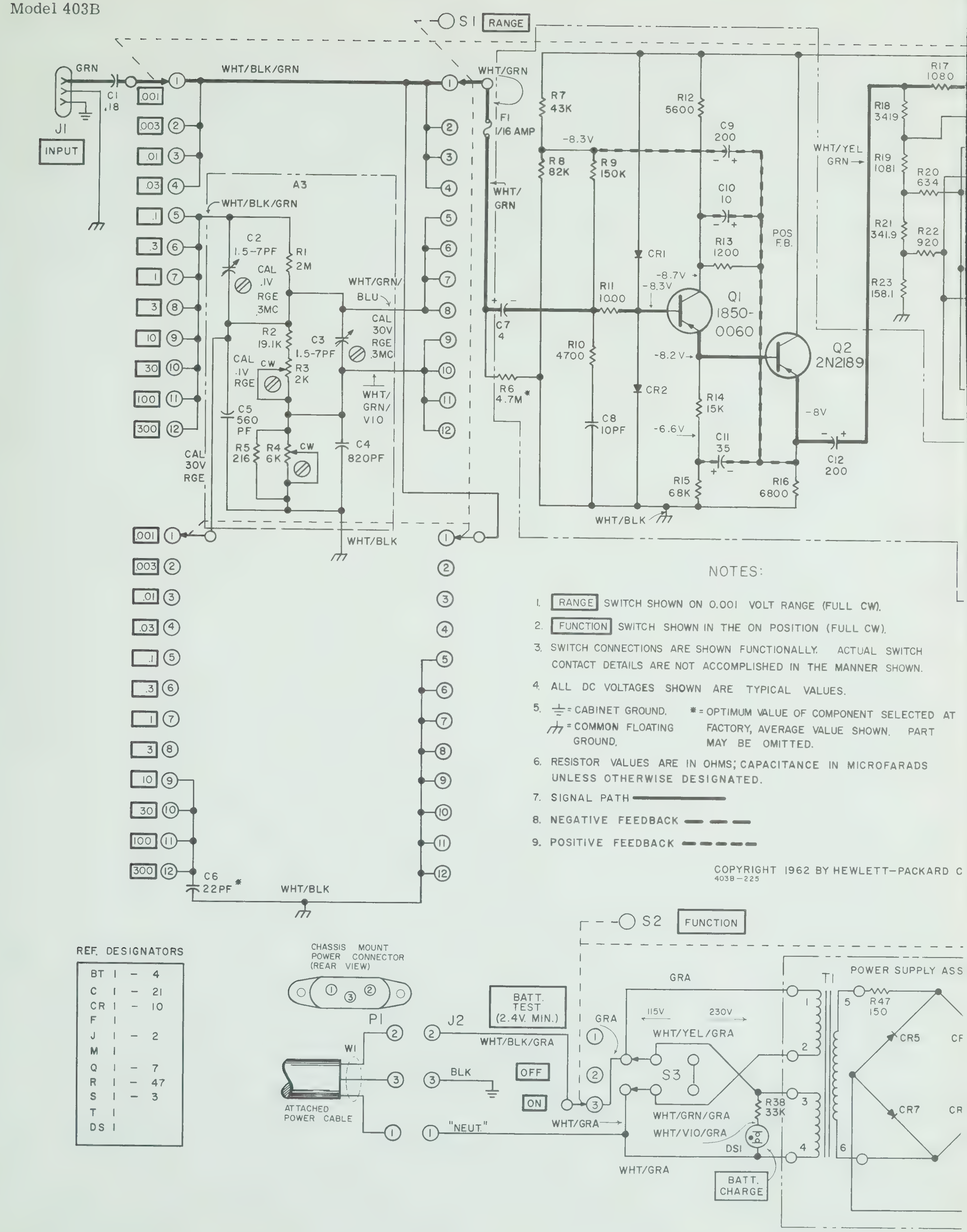
South Africa
F. H. Flanter & Co. (Pty.), Ltd.
Rosella House
Buitencingle Street, Cape Town
Tel: 3-3817

Taiwan (Formosa)
Hwa Sheng Electronic Co., Ltd.
21 Nanking West Road, Taipei
Tel: 4-6076, 4-5936

✦ Indicates Instrument Repair Stations

MARCH 1964

NOTES

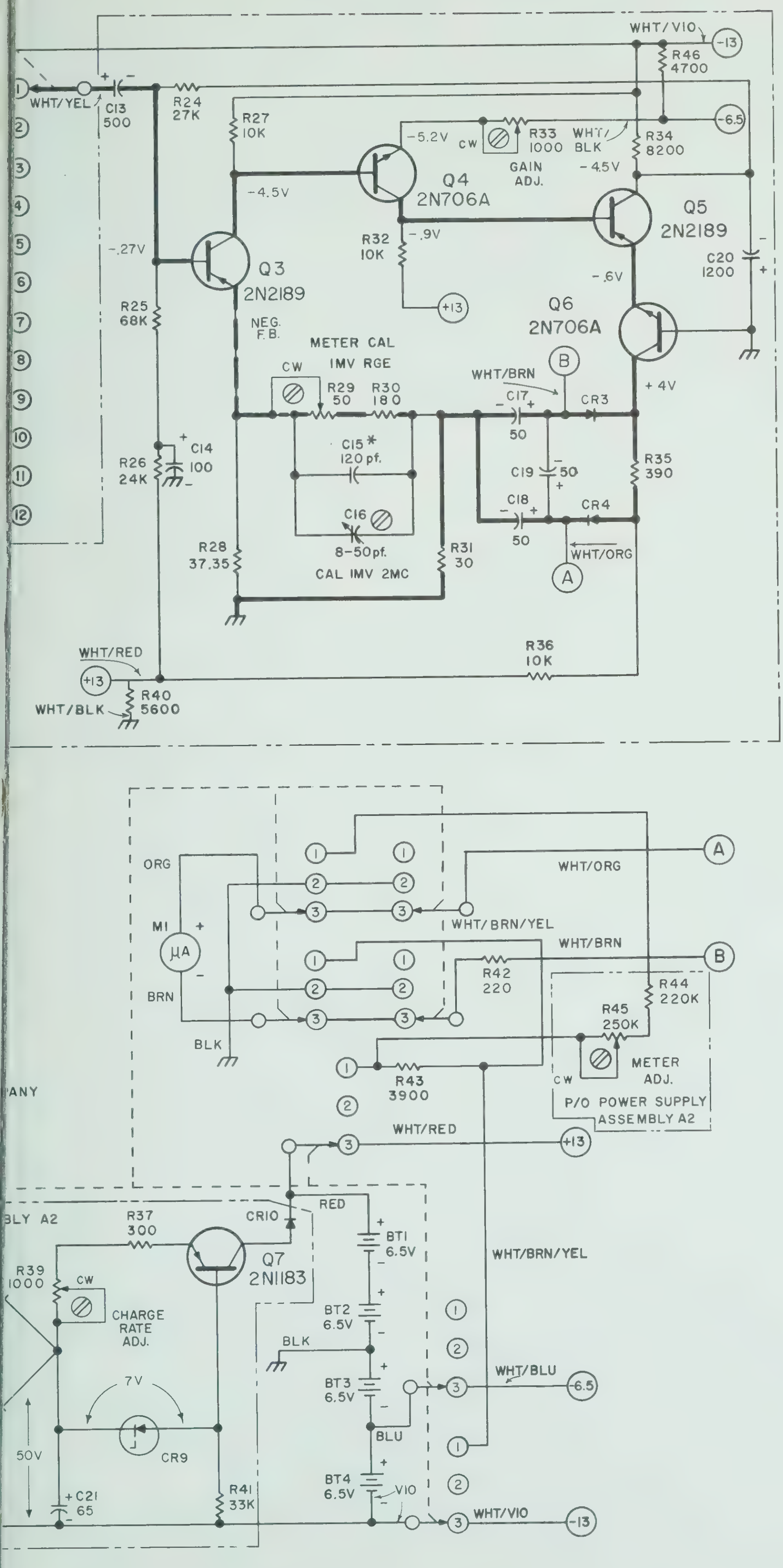


NOTES:

1. RANGE SWITCH SHOWN ON 0.001 VOLT RANGE (FULL CW).
2. FUNCTION SWITCH SHOWN IN THE ON POSITION (FULL CW).
3. SWITCH CONNECTIONS ARE SHOWN FUNCTIONALLY. ACTUAL SWITCH CONTACT DETAILS ARE NOT ACCOMPLISHED IN THE MANNER SHOWN.
4. ALL DC VOLTAGES SHOWN ARE TYPICAL VALUES.
5. = CABINET GROUND. = COMMON FLOATING GROUND. * = OPTIMUM VALUE OF COMPONENT SELECTED AT FACTORY, AVERAGE VALUE SHOWN. PART MAY BE OMITTED.
6. RESISTOR VALUES ARE IN OHMS; CAPACITANCE IN MICROFARADS UNLESS OTHERWISE DESIGNATED.
7. SIGNAL PATH
8. NEGATIVE FEEDBACK
9. POSITIVE FEEDBACK

4038-225

Figure 5-8. Schematic Diagram


WHT/VIO
-13
R46
4700
WHT/YEL
C13
500
R24
27K
R27
10K
-5.2V
CW
R33
1000
GAIN
ADJ.
WHT/
BLK
R34
8200
-6.5
-4.5V
Q4
2N706A
-4.5V
Q5
2N2189
R32
10K
-.9V
-.27V
Q3
2N2189
C20
1200
-.6V
+13
Q6
2N706A
R25
68K
NEG.
F.B.
METER CAL
IMV RGE
CW
R29
50
R30
180
WHT/BRN
B
C17
CR3
+4V
50
C15*
120 pf.
R26
24K
C14
100
C19
50
R35
390
C18
CR4
C16
50
8-50pf.
CAL IMV 2MC
R28
37.35
R31
30
WHT/ORG
A
WHT/RED
+13
R36
10K
R40
5600
WHT/BLK
ORG
A
WHT/ORG
M1
μA
WHT/BRN/YEL
WHT/BRN
B
BRN
R42
220
R44
220K
R45
250K
BLK
METER
ADJ.
CW
R43
3900
P/O POWER SUPPLY
ASSEMBLY A2
WHT/RED
+13
BLY A2
R37
300
CR10
RED
BT1
6.5V
Q7
2N1183
R39
1000
CW
CHARGE
RATE
ADJ.
WHT/BRN/YEL
BT2
6.5V
BLK
BT3
6.5V
WHT/BLU
-6.5
7V
BLU
50V
CR9
BT4
6.5V
VIO
C21
65
R41
33K
WHT/VIO
-13

'ANY

WARRANTY

All our products are warranted against defects in materials and workmanship for one year from the date of shipment. Our obligation is limited to repairing or replacing products (except tubes) which prove to be defective during the warranty period. We are not liable for consequential damages.

For assistance of any kind, including help with instruments under warranty, contact your nearest Hewlett-Packard field office for instructions. Give full details of the difficulty and include the instrument model and serial numbers. Service data or shipping instructions will be promptly sent to you. There will be no charge for repair of instruments under warranty, *except transportation charges*. Estimates of charges for non-warranty or other service work will always be supplied, if requested, before work begins.

CLAIM FOR DAMAGE IN SHIPMENT

Your instrument should be inspected and tested as soon as it is received. The instrument is insured for safe delivery. If the instrument is damaged in any way or fails to operate properly, file a claim with the carrier or, if insured separately, with the insurance company.

SHIPPING

On receipt of shipping instructions, forward the instrument prepaid to the destination indicated. You may use the original shipping carton or any strong container. Wrap the instrument in heavy paper or a plastic bag and surround it with three or four inches of shock-absorbing material to cushion it firmly and prevent movement inside the container.

GENERAL

Your nearest Hewlett-Packard field office is ready to assist you in any situation, and you are always welcome to get directly in touch with Hewlett-Packard service departments:

CUSTOMER SERVICE

Hewlett-Packard Company
395 Page Mill Road
Palo Alto, California, 94306
U.S.A.
Telephone: (415) 326-3950
TWX No. (415) 492–9363
Cable: "HEWPACK"

OR (In Western Europe)

Hewlett-Packard S.A.
54 Route Des Acacias
Geneva, Switzerland
Telephone: (022) 42. 81. 50
Cable: "HEWPACKSA"

PRINTED IN U.S.A

HEWLETT-PACKARD COMPANY / OPERATING AND SERVICE MANUAL

403B

TRANSISTORIZED AC VOLTMETER

CERTIFICATION

THE HEWLETT-PACKARD COMPANY CERTIFIES THAT THIS INSTRUMENT WAS THOROUGHLY TESTED AND INSPECTED AND FOUND TO MEET ITS PUBLISHED SPECIFICATIONS WHEN IT WAS SHIPPED FROM THE FACTORY.

hp FURTHER CERTIFIES THAT ITS CALIBRATION MEASUREMENTS ARE TRACEABLE TO THE NATIONAL BUREAU OF STANDARDS TO THE EXTENT ALLOWED BY THE BUREAU'S CALIBRATION FACILITY.

hp MANUAL CHANGES

MODEL 403B

TRANSISTORIZED AC VOLTMETER

Manual Serial Prefixed 225-
Manual Printed 12/62

To adapt this manual to instruments with other serial prefixes check for errata below, and make changes shown in tables.

Instrument Serial Prefix	Make Manual Changes	Instrument Serial Prefix	Make Manual Changes
ALL	ERRATA		
225-	1		

ERRATA: Paragraph 5-40, FREQUENCY RESPONSE

DELETE: Step h.

ADD: Step h. as follows:

"h. Repeat step g, adjusting RANGE SELECTOR and FREQ TUNING on Model 739AR for 1 mc."

ADD: Step i. as follows:

"i. Adjust the RANGE SELECTOR and FREQ TUNING on Model 739AR for 2 mc. Set Model 739AR to SET LEVEL with the oscillator AMPLITUDE control The Model 403B should read .9 of full scale ±0.45 mv (±5%)."

ERRATA: Paragraph 5-29, POWER SUPPLY

Step a. Was Remove Bottom cover from 403B cabinet
Now Remove Left side cover from 403B cabinet

Step f. Was . . . located in the upper right. . .
Now . . . located in the lower right. . .

Paragraph 5-30, TRACKING AND CALIBRATION

Step h. Was . . . full scale indication on the 10 volt. . .
Now . . . full scale indication on the 30 volt. . .

Paragraph 5-33, 30-VOLT RESPONSE

Step e. DELETE: Step e
ADD: Step e as follows:

"e. Verify that the 403B reading at 300kc is the same as the reading of the 403B at 400cps in step c. If not, adjust C3 until the reading is the same.

Paragraph 5-36, ALTERNATE METHOD

DELETE: Step i.
ADD: Step i. as follows:

"i. For 30 volt response checks follow procedure in paragraph 5-33, steps a through e."

CHANGE #1 Table 6-1 of Replaceable Parts
ADD to Miscellaneous:

M1 (Optional), hp Stock No. 403B-81B, Description: Meter DB (DB (DB Meter standard on Model 3550A Portable Test Set).

Instrument Serial Prefix	Make Manual Changes
ALL	ERRATA
225-	1

Instrument Serial Prefix	Make Manual Changes

ERRATA: Paragraph 5-34,

Step a: Change to read, "Turn the 403B ON. . . . . "

Step c: Change to read, "With the 403B set to the 0. 1 volt RANGE, the reading on the 403A/B should be less than 3. 3 volts.

ERRATA: Paragraph 5-26, Noise Check,

Add:

NOTE

This Noise Check is to be made on Battery Operation only. Do not connect 403B to an AC source.

OPERATING AND SERVICING MANUAL

MODEL 403B

Serials Prefixed: 225

TRANSISTORIZED AC VOLTMETER

01325-1

Printed: DEC 1962

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

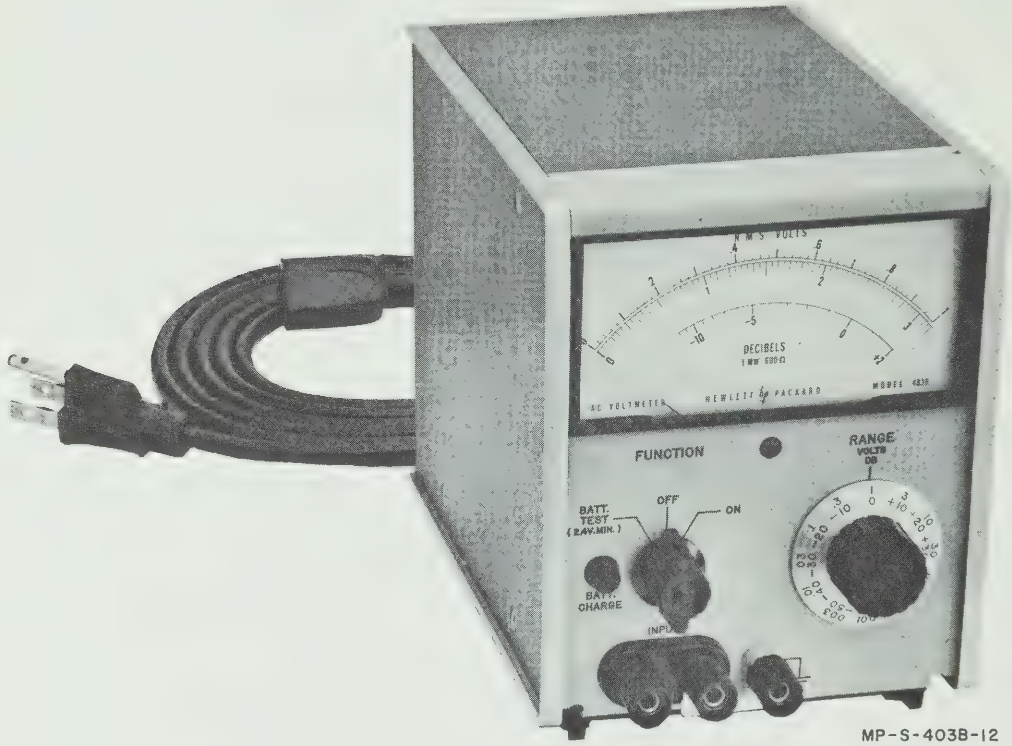


Figure 1-1. Model 403B Transistorized AC Voltmeter

Table 1-1. Specifications

RANGE:
0.001 to 300 volts rms full scale (12 ranges) in a 1, 3, 10 sequence. -72 dbm to +52 dbm.

FREQUENCY RANGE:
5 cycles per second to 2 mc.

ACCURACY:

Temperature	Frequency		
	5 to 10 cps	10 cps to 1 mc	1 to 2 mc*
0°C to $+50^{\circ}$C	±5%	±2%	±5%
-20°C to 0°C	±8%	±8%	±8%

* ±10% on 300 v range. Use AC-21A 10:1 Divider and AC-76B Adapter shunted by a 2 megohm resistor to retain ±5% accuracy while measuring up to 425 v rms at 1 to 2 mc.

METER:
Responds to average value of input waveform and is calibrated in the rms value of a sine wave.

OVERLOAD PROTECTION;
Fuse protected.

NOMINAL INPUT IMPEDANCE:
2 megohms: shunted by approximately 40 pf on 0.001 volt to 0.03 volt ranges, 25 pf on 0.1 volt to 300 V.

OVERLOAD PROTECTION:
Fuse protected.

DC ISOLATION:
Signal ground may be ±500 vdc from external case.

POWER SUPPLY:
4 rechargeable batteries (furnished). 40 hour operation per recharge (20 hours at -20°C), up to 500 recharging cycles. Recharging circuit is self-contained and functions automatically when instrument is operated from ac line (115 or 230V ±10%, 50 to 1000 cps, approx. 3 watts).

TEMPERATURE RANGE:
-20° C to $+50^{\circ}$C.

DIMENSIONS:
6-3/32 in. high, 5-1/8 in. wide, 8 in. deep.

WEIGHT:
6-1/2 pounds

SHIPPING WEIGHT: 10 pounds

SECTION I

GENERAL INFORMATION

1-1. DESCRIPTION

1-2. The hp Model 403B is a general purpose electronic AC voltmeter, having full scale ranges from 1 mv to 300 volts in a 1, 3, 10 sequence. The meter face is calibrated in db from -12 to +2 db. When combined with the range switch full scale ranges of -60 to +52 db will give a total range of -72 to +50 db. This instrument will accurately measure voltages at any frequency between 5 cps and 2 mc. The meter circuit responds to the average value of the wave shape applied and is calibrated in terms of the rms value of a sine wave.

1-3. The 403B AC Voltmeter is transistorized and operates on Nickel Cadmium batteries. This instrument has a self-contained battery charger which operates on 115 or 230 volts AC.

CAUTION

A switch located on the rear of the instrument enables the user to select either 115 or 230 volt position, when applying AC power to the hp 403B.

When the power cable is connected to an AC source, the power supply (battery charger) is feeding energy to the instrument.

Note

The 403B will not function with the batteries removed from the instrument.

The batteries make up a voltage divider supply negative and positive voltage to the instrument. The power supply in the 403B is continually charging the batteries when the function switch is placed to the "ON" position and the line cord is connected to a 115 or 230 volt AC source. The batteries cannot be overcharged. In the event of complete discharge, the 403B can be used after twenty minutes of recharging with the line cord connected to an AC source. Complete recharge requires approximately 60 hours of charging time. Refer to section 4-25.

The 403B is widely useful as a laboratory voltmeter especially on battery operation. This supply allows measurements to be made with the instrument isolated from power line ground. By disconnecting the ground strap between the two black input terminals, the outer case of the 403B is isolated up to 500 vdc from the instrument's ground.

Table 1-2. Accessories Available

Model No.	Use	Features		
AC-16S AC-16T	Test Leads	Dual Banana Plug to Alligator Clips Dual Banana Plug to Probe and Alligator Clip		
AC-21J	10:1 Divider	10 Megohms probe		
AC-76B	Adapter	Binding post to BNC		
AC-60B	Line Bridging Transformer Provides balanced 600 ohm input to unbalanced 600 ohm output for measurements on balanced lines.	Terminating Resistance: 600 or 10K ohms Frequency Range: 20 cps to 45 kc Power Handling Capacity: +15 dbm (4.5v into 600Ω)		
452A	Capacitive Voltage Divider (Division ratio: 1000:1)	Accuracy: ±3% Input Capacity: 15 pf ±1 pf Max. Voltage Rating: 60 cps 25 kv, 100 kc 22kv, 1 mc 20 kv, 10 mc 15 kv, 20 mc 7 kv.		
		Resistance	Max. Current	Accuracy
470A 470B 470C 470D 470E 470F	Shunt Resistors For adapting the 403B to current measurements (1 μa to 3 amps full scale, 1 watt maximum).	0. 1 ohm 1 ohm 10 ohms 100 ohms 600 ohms 1000 ohms	3 amps 1 amp 300 mg 100 ma 41 ma 30 ma	470A only: ±1% to 100 kc ±5% to 1 mc all others: ±1% to 100 kc ±5% to 4 mc
456	AC Current Probe 1 mv/ ma ±1% at 1 kc	negligible	1 amp rms 1.5 amp peak	±2% 100 cps to 3 mc

1-4. DIFFERENCES BETWEEN INSTRUMENTS

1-5. The Model 403B carries a five-digit serial number with a three-digit prefix (000-00000). The prefix changes only when a change is made in the instrument. The prefix, then, is an identifier, and it appears on the title page of this manual to indicate to which instrument this manual directly applies. A supplement may be included with this manual to indicate the necessary changes to be made in the manual to make the manual apply directly to Models 403B which carry a different serial number prefix.

1-6. ACCESSORIES AVAILABLE

1-7. Table 1-2 and Figure 1-2 illustrate accessories which are made by Hewlett-Packard to increase the usefulness of your voltmeter.

AC-60B Line Bridging Transformer

Model 452A Capacitive Voltage Divider

AC-76B Adapter

AC-21J 10:1 Divider Probe

Figure 1-2. Accessories Available

SECTION II

INSTALLATION

2-1. INSPECTION

2-2. Unpack the instrument upon receipt and inspect it for signs of physical damage such as scratched panel knobs, etc. If there is any apparent damage, file a claim with the carrier and refer to the warranty page on the back of this manual.

2-3. An electrical inspection should be performed as soon as possible after receipt. To aid in electrical inspection, performance checks are included in section V, paragraph 5-38.

2-4. POWER REQUIREMENTS

2-5. The Model 403B operates on Nickel Cadmium batteries. This instrument uses four 6.5 volt cells and, under continuous operation, over 40 hours of service is obtained from the batteries before recharging. The 403B can be operated on 115 or 230 volts AC. This instrument is continually charging the batteries whenever the function switch is on and the line cord is connected to a 115 or 230 volt source.

CAUTION

A switch located on the rear of the instrument enables the user to select the 115 or 230 volt position when applying AC power to this instrument.

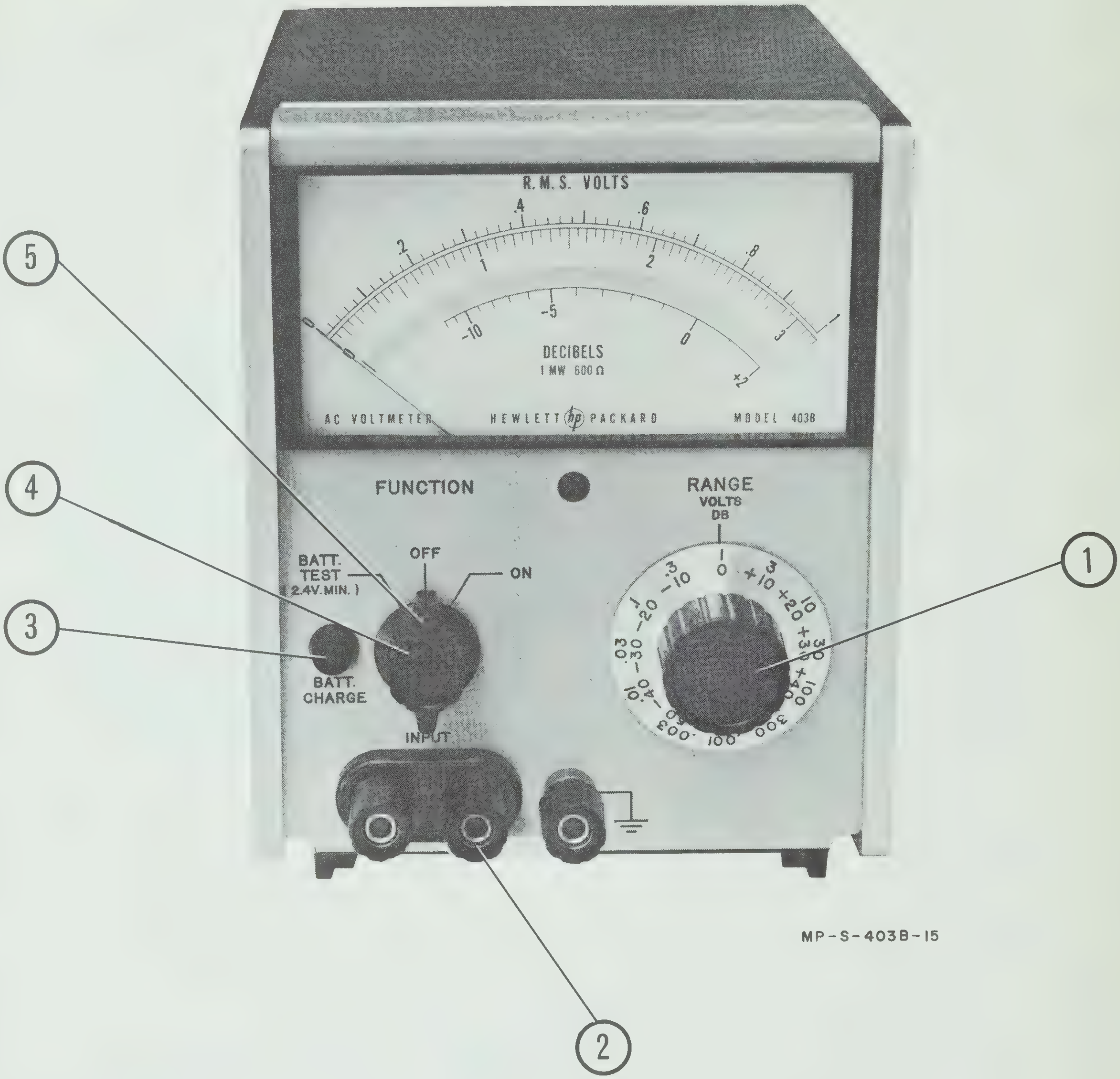
2-6. INSTALLATION

2-7. The voltmeter is a portable instrument requiring no permanent installation. The Model 403B uses a 1/3 module cabinet. Rack mounting information is available by contacting your local ⓗ representative.

2-8. REPACKING FOR SHIPMENT

2-9. When returning an instrument to the Hewlett-Packard Company, use the original packing material (only if foam type) if available or contact your authorized Hewlett-Packard Engineering Representative for assistance. If this is not possible, first protect the instrument surfaces with heavy Kraft paper or with sheets of cardboard flat against the instrument. Then protect the instrument on all sides, (use approximately 4 inches of packing material designed specifically for package cushioning), pack in a durable carton, mark carton clearly for proper handling, and insure adequately before shipping. Original packing materials which are a cardboard "accordion-like" filler are not recommended for reshipment since the cushioning ability is usually destroyed with one use.

2-10. When returning an instrument to the Hewlett-Packard Company for service or repair, attach a tag to the instrument specifying the owner and desired action. All correspondence should identify the instrument by Model number and the full serial number.



1. RANGE switch -

   Select range which gives a reading in the upper 2/3 of the meter scale.

2. INPUT terminals -

   Connect voltage to be measured to these terminals.

3. BATT. CHARGE indicator -
   Glows when instrument is connected to an AC source with the function switch turned to the "ON" position.

4. FUNCTION switch -

   Check battery condition by rotating the switch to the BATT. TEST position. The meter should read above 2. 4 volts on the "0-3" meter scale.

5. Fluorescent indicator -

   Glows when instrument is on.

Figure 3-1. Operating Controls

SECTION III

OPERATING INSTRUCTIONS

3-1. INTRODUCTION

3-2. This voltmeter is ready for use as received from the factory and will give specified performance after a short warmup period. Allow approximately 20 seconds warmup for optimum performance.

3-3. OPERATION

3-4. Connect voltage to be measured to the center black terminal and the red terminal. The outer black terminal is connected to the instrument case and has a nominal value of 300 pf capacitance to the instrument's electrical ground.

3-5. RANGE SWITCH

3-6. Select range which gives a reading in the upper 2/3 of the meter scale (to obtain highest accuracy).

3-7. The meter has two VOLTS scales, 0 to 1 and 0 to 3. When the RANGE switch is set to .001, .01, .1, 1, 10 or 100 VOLTS, read the 0 to 1 scale. When the RANGE switch is set to .003, .03, .3, 3, 30 or 300 VOLTS read the 0 to 3 scale.

3-8. FUNCTION SWITCH

3-9. Check battery condition by rotating the switch to BATT TEST position. The meter should read 2.4 volts or above on the 3 volt scale.

3-10. Recharging is necessary when the ⓗⓟ 403B battery voltage reads below 2.4 volts as read on the 3.0 volt scale when the ⓗⓟ 403B function switch is in the BATT. TEST position. This corresponds to a battery voltage of 24 volts.

3-11. To recharge the batteries, merely insert the power cord into AC supply and turn function switch to ON. The ⓗⓟ 403B AC Voltmeter can be used while recharging the batteries.

CAUTION

A switch located on the rear of the instrument enables the user to select the 115 or 230 volt position power line voltage.

3-12. The 403B has a self-contained battery charger. This instrument is continually charging the batteries whenever the FUNCTION switch is ON and the line cord connected to a 115 or 230 volt source. In the event of complete discharge, the 403B can be used after twenty minutes of recharging with the line cord connected to an AC source. Complete recharge requires approximately 60* hours when the nickel cadmium cells are completely discharged. (Refer to Section IV Paragraph 4-25).

*Depending on setting of R-39.

CAUTION

The four nickel cadmium batteries in the ⓗⓟ 403B are in hermetically sealed containers. The user must be cognizant of temperature extremes while charging the batteries. Under high temperatures (above 50° C), hydrogen in the hermetically sealed battery container can build up to large pressure, causing damage to the batteries and/or instrument. Refer to Section IV, Page 4-3 Caution Note.

3-13. The fluorescent indicator on the FUNCTION switch glows when the instrument is in the ON position. This device operates on reflected room light and will not work in the dark. The BATT. CHARGE light glows when the instrument is turned on, and connected to a 115 or 230 AC source.

3-14. VOLTAGE MEASUREMENTS

3-15. If measurements are made from a high impedance source, hum pick-up can affect the meter indication because of the high impedance of both the source and the voltmeter. Shielded leads will reduce pick-up although they will cause an increase in the capacity shunted across the source, with the possibility of excessive circuit loading.

3-16. The rated 2 megohms input resistance will be effectively reduced (above 1 kc) by shunt input capacity. (This fact is true for any ac voltmeter). 50 pf has a reactance of .8 megohm at 4 kc, 80,000 ohms at 40 kc, etc. The shunt capacity decreases on the higher ranges (see specifications). This factor should be considered when measuring higher frequency voltages in circuits of moderate impedance level.

NOTE

By disconnecting the ground strap between the two black input terminals, the outer case of the 403B is isolated up to 500 vdc from the instrument's ground.

3-17. Severe RF circulating currents are generated at potentials approaching 300 volts in the 1 to 2 mc frequency range. These severe ground currents limit the accuracy of the 403B to ±10% on the 300 volt range. By using ⓗⓟ accessories AC-21B (10:1 divider) and AC-76B (adapter) shunted by a 2 megohm resistor, the accuracy of the 403B can be retained to ±5%.

3-18. A 1/16 ma fuse is included in series with the input circuit which will blow with repeated or excessive overload. This fuse is accessible when the cabinet is removed. A spare fuse is included inside the instrument.

3-19. Always leave the instrument on the 1 volt range or higher when making initial connections to circuits which have dc levels over 25 volts. Then switch to the appropriate lower range to obtain an up-scale reading. This practice should be applied when making power supply ripple measurements where the dc voltage may be as much as 600 volts but the ac ripple is only a few millivolts.

3-20. AMBIENT TEMPERATURE LIMITS

3-21. This instrument has certain temperature limitations. The design of this instrument has provided for safe and stable operation over the range of -20 to +50°C (-4 to +122°F). This temperature range is quite adequate for most users, however keep these limits in mind when operating under field conditions. Internal temperatures in excess of 122°F are quite easy to obtain if the instrument is left in the sun, even if the air temperature is quite moderate. A good practice is to be certain that the instrument is not stored or operated in direct sunlight to avoid the possibility of reduced performance. When using 403B at temperatures below 0°C, be certain the batteries are fully charged prior to subjecting instrument to this temperature.

CAUTION

Nickel-Cadmium cells in this instrument are hermetically sealed. Damage to cells may occur if exposed to extremely high temperatures.

3-22. WAVEFORM ERRORS

3-23. In order to maintain accuracy of measurement, one must remember that this instrument is an average responding device, but the meter scale is calibrated in terms of the rms value of a pure sine wave. If the waveform of the voltage being measured contains appreciable harmonics or other spurious voltages, the meter indication will deviate from the true rms value on the order indicated by table 3-1.

Table 3-1. Effect of Harmonics on Model 403B Voltage Measurements

Input Voltage Characteristics	True RMS Value	Value Indicated by 403B
Fundamental = 100	100	100
Fundamental +10% 2nd harmonic	100.5	100
Fundamental +20% 2nd harmonic	102	100 - 102
Fundamental +50% 2nd harmonic	112	100 - 110
Fundamental +10% 3rd harmonic	100.5	96 - 104
Fundamental +20% 3rd harmonic	102	94 - 108
Fundamental +50% 3rd harmonic	112	90 - 116

3-24. This table is a general one and applies to any average responding rms calibrated voltmeter. As can be seen in the table, errors are small even with a badly distorted signal (i. e.; 20% 2nd harmonic gives +0, -2% error).

3-25. DECIBEL MEASUREMENTS

3-26. Measurements in terms of decibels are made in the same way as voltage measurements except that the indication is read on the db scale (-12 to +2 db). The decibel level is the algebraic sum of the meter db scale indication and DB VOLTS (RANGE) position.

3-27. To read power directly in dbm (0 dbm=1 milliwatt into 600 ohms) the measurement must be made across 600 ohms. Comparative db measurements (without respect to reference level) may be obtained by direct reading provided each measurement is made across the same impedance value. The difference in decibels between two or more measurements may be obtained by reading directly from the db-scale indications. (For examples of db measurements refer to table 3-2).

Table 3-2. Examples of Voltage and DB Measurements

Range Switch	Meter Scale	Meter Indicates	Actual Level
Voltage measurements:			
300	3	1.8	180
10	1	0.44	4.4
.003	3	2.3	.0023
.001	1	.27	.00027
DB measurements:			
+40 db	db	+2 db	+42 db
+40 db	db	-7 db	+33 db
+10 db	db	-6 db	+ 4 db
-30 db	db	0 db	-30 db
-30 db	db	-8 db	-38 db
*-50 db	db	-9 db	-59 db
-60 db	db	+1 db	-59 db

*NOTE: In cases where a meter scale reading below -8 db is obtained, it is best to switch to the next lower range on the instrument so a reading will be obtained in the upper portion of the scale where highest accuracy may be obtained.

The same situation exists for voltage measurements. When a reading is obtained in the lower 1/3 scale, the range switch should be switched to the next lower range to obtain a reading in the upper 2/3 scale.

3-28. IMPEDANCE CORRECTION GRAPH

3-29. To obtain the level in dbm with respect to impedances other than 600 ohms, the meter correction

graph shown in figure 3-2 may be used. The level in dbm will be the algebraic sum of the level as indicated on the meter and the correction shown on the graph. For example, if the range switch is at the +30 db position, the measurement made across 90 ohms, and the indication on the DB scale +1, the level in dbm is obtained as follows:

+ 1	(db scale indication)
+30	(range switch position)
+31	(level in db as indicated by meter)
+ 8	(correction for 90 ohms impedance).
+39	dbm

3-30. For the same conditions, with the measurement made across 10, 000 ohms:

+ 1	(db scale indication)
+30	(range switch position)
+31	(level in db as indicated by meter)
-12. 5	(correction for 10, 000 ohms impedance)
+18. 5	dbm

3-31. CURRENT MEASUREMENTS

3-32. SHUNT RESISTORS

3-33. The hp Model 470A through Model 470F Shunt Resistors (table 1-2) are available to convert your Model 403B into a current measuring device. These resistors make possible current readings of from 1 μ amp to 3 amps full scale.

3-34. To use the Model 470 series resistors, proceed as follows:

a. Plug resistor into Model 403B input terminals.

b. Plug connector from circuit under test into shunt resistor.

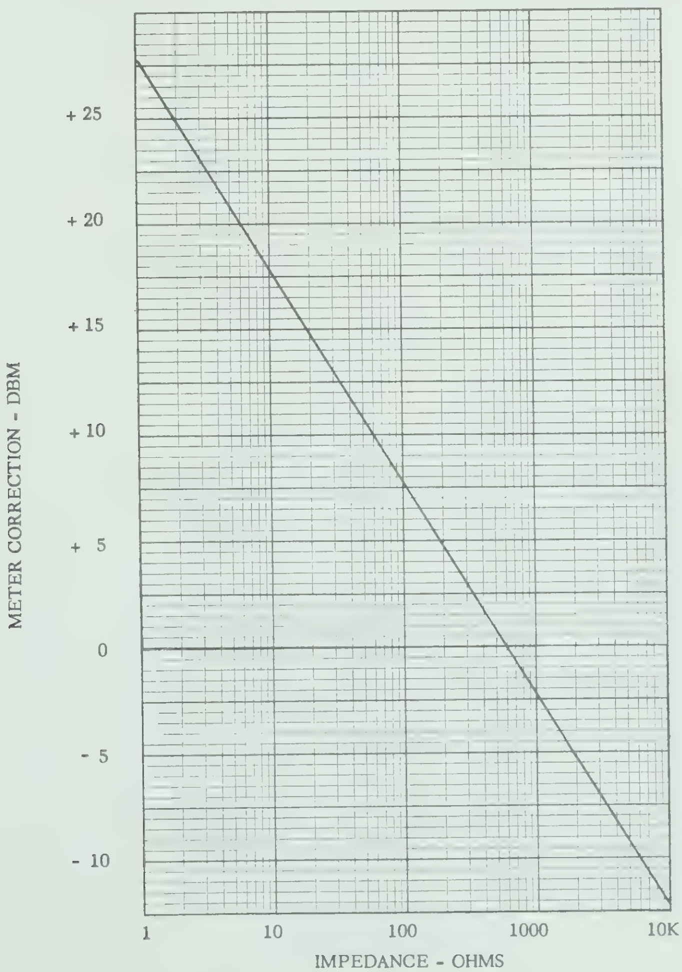
c. Divide resistance value used into the reading on the Model 403B to get the actual current.

3-35. CLIP ON PROBE

3-36. The hp Model 456A Current Probe provides quick measurement of current from 1 ma to 1 amp full scale with minimum circuit loading.

3-37. To use the Model 456A, simply clamp the probe around the current carrying wire and plug the output into the Model 403B. The probe output is 1 mv/ma.

Figure 3-2. Model 403B Impedance Correction Graph



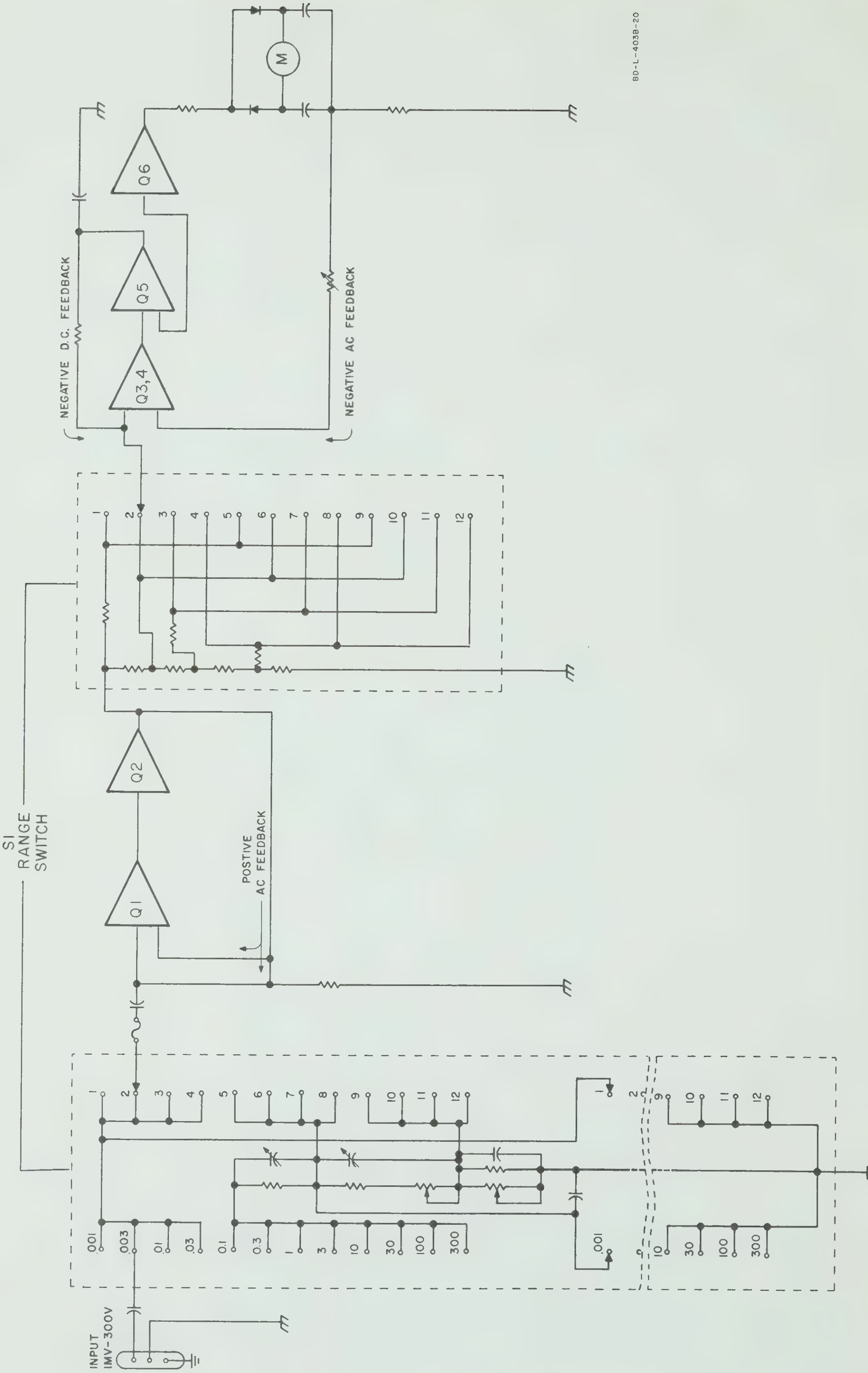


Figure 4-1. Model 403B Functional Block Diagram

SECTION IV
CIRCUIT DESCRIPTION

4-1. INTRODUCTION

4-2. The Model 403B consists essentially of a preliminary input attenuator, a high impedance emitter follower circuit, a range attenuator and a wide range fixed gain amplifier. Refer to Figure 4-1.

4-3. PRELIMINARY ATTENUATOR

4-4. The RANGE switch is divided up into two sections: the preliminary attenuator, located between the input terminals and Q1, and the intermediate attenuator, located between Q2 and Q3. The preliminary input attenuator has two ranges, 100:1 and 10,000:1, which are switched in at the appropriate time to keep the input voltage to Q1 less than .030 volt. This not only prevents overloading the input system, but also provides the necessary accurate attenuation to work with the intermediate attenuator to produce the conventional 1, 3, 10 sequence for correct meter operation.

4-5. The attenuators are of the compensated resistor capacitor (rc) type, with the capacitive division ratio made equal to the resistive ratio to maintain a constant division ratio at all frequencies. By making one of the capacitors adjustable, the small variations in stray circuit capacity can be compensated for, so the voltmeter will have a flat response. The exact division ratio is set at low audio frequencies by the trimmer potentiometers, which bring the resistor division ratio to the exact value.

4-6. INPUT CIRCUIT

4-7. R11, CR1, and CR2 make up a limiting circuit which is used for overload protection to prevent high instantaneous voltages from being impressed on the base of Q1. F1 is a 1/16 amp fuse used to protect the 403B against a continuous or repeated overload.

4-8. Since transistors are inherently low impedance devices, a need for a high input impedance is required. Referring to figure 4-2, it would seem that the input resistance of the first stage would be approximately R_i of a grounded collector configuration in parallel with R9, plus the R7-R8 combination. Q1 and Q2 are emitter followers, exhibiting unity gain and no phase reversal. (R_i = approx. input Z of a common collector stage).

4-9. The output of Q2 is fed back to the junction of R9 and R7-R8. There is an ac voltage existing at this point that is very nearly the same amplitude as the input voltage. Since a very small ac voltage exists across R9, the input current I_{in} will be very small. Thereby:

$$Z_{in} = \frac{E_{in}}{I_{in}}$$

It can be seen that when I_{in} is very small, the apparent Z_{in} becomes very large.

4-10. The R_i of Q1 is increased in a similar manner by feeding the Q2 emitter voltage to both the collector and emitter of Q1.

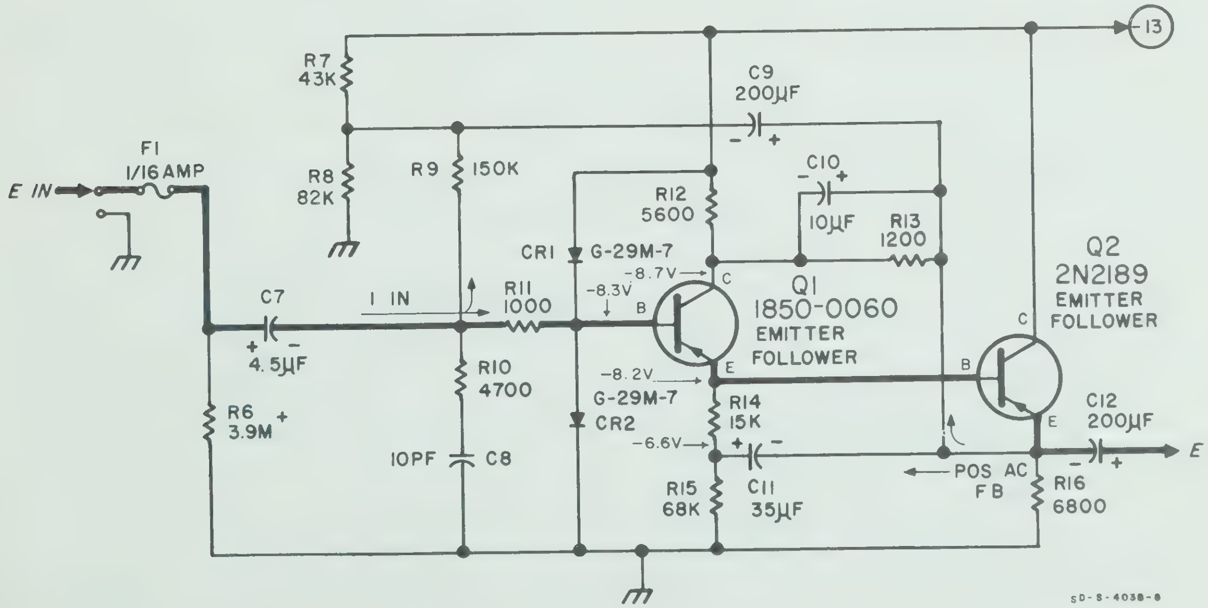


Figure 4-2. Input Amplifier

4-11. INTERMEDIATE ATTENUATOR

4-12. The output of Q2 is fed to the intermediate section of the range attenuator. The range attenuator is a voltage divider, in sequence with the preliminary attenuator. A 1, 3, 10, etc., ratio is obtained resulting in 10 DB steps. Refer to Figure 4-1.

4-13. Refer to schematic diagram (Figure 5-11) in the back of this manual.

4-14. Transistors Q3 through Q6 make up the fixed gain amplifier which is used to develop the current for (full scale) meter deflection and to provide the meter circuit with a high impedance source for linear operation at all current levels.

4-15. The output of the intermediate range attenuator is fed to the base of Q3 (differential amplifier), and compared with a feedback signal to its emitter from the meter circuit. This difference signal is fed to Q4 which in turn is directly coupled to Q5 and Q6. Q4 is a grounded emitter amplifier. Q5 is a common collector amplifier which impedance matches Q6, a common base amplifier. The direct couple feature of the amplifiers is necessary because of the low-frequency (5 cycle) response of the 403B. R24 through R26 make up the dc feedback loop which tends to minimize any tendency for dc drift due to ambient temperature change. R33 corrects the total gain of Q3 through Q6.

4-16. The meter source impedance is increased by the use of negative feedback from the output of the meter rectifier bridge to the emitter of Q3. Resistor R28 through R30, and C15 and C16 correct the phase of the feedback at high frequencies.

4-17. The necessity of high meter source impedance can be explained by referring to figures 4-3 and 4-4.

4-18. To have correct voltmeter action it is necessary that the change in meter current be proportional to a change in amplifier input voltage. The load resistance, then, should remain constant. Note from figure 4-3, however, that when I_O (and therefore the diode voltage Ed) decreases, the diode resistance Rd (and therefore the load resistance) increases, affecting meter linearity. Note in figure 4-4 that Rd appears in series with Ro, the source impedance. The effect on output current, of changes in diode resistance with voltage, can be minimized by feeding the meter circuit from a constant current or high impedance source. In this way, changes of diode resistance will have a negligible effect on the total current passing through them and hence through the meter.

4-19. The effect of diode resistance change is further minimized by Q6 current through R35 which impresses a fixed .3 volt across CR3 and CR4, biasing them close to their contact potential.

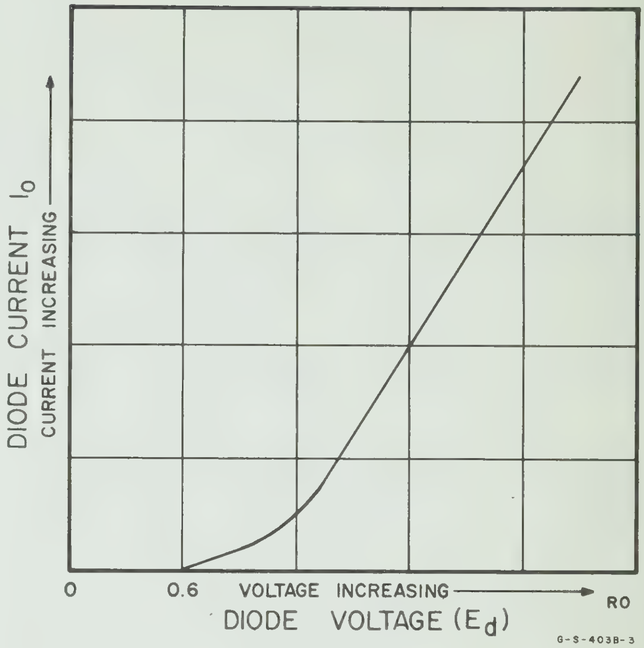


Figure 4-3. Diode Current Vs Diode Voltage

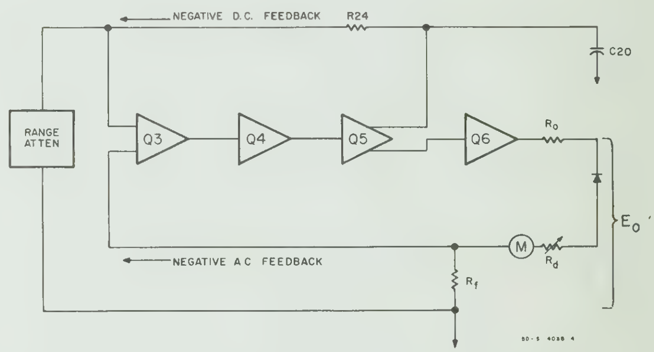


Figure 4-4. Fixed Amplifier Block Diagram

4-20. METER RECTIFIER CIRCUIT

4-21. The meter rectifier circuit is arranged in a bridge-type configuration, with a crystal diode and a capacitor in each branch and a dc microammeter connected across its midpoints. The current through the meter is proportional to the average value of the input voltage waveform. Since calibration of the meter in rms volts is based on the ratio that exists between the average and effective values of a sine-wave voltage.

4-22. The 403B meter rectifier circuit operation can best be explained by analyzing the circuit in a simpli-

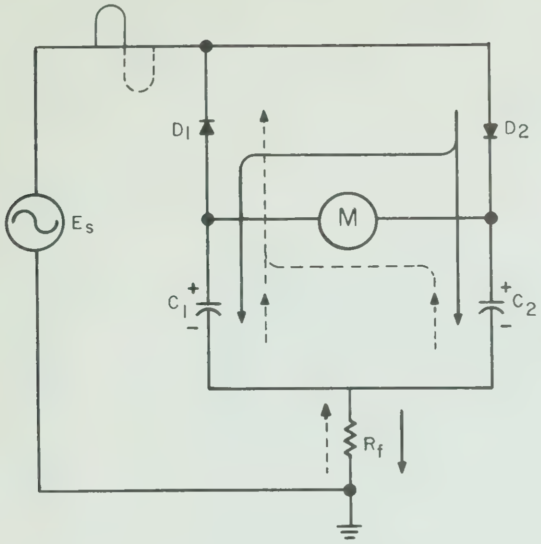


Figure 4-5. Meter Rectifier, Simplified Diagram

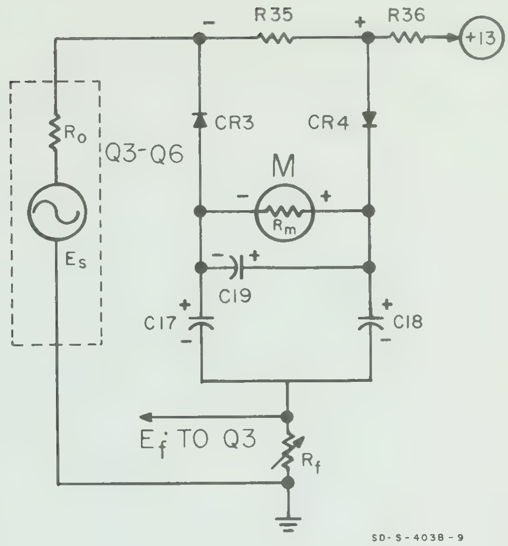


Figure 4-6. Meter Rectifier Circuit

fied form. Figure 4-5 shows a voltage source generating a voltage E_s across a circuit made up of D_1, D_2, M_1, R_f, and C_1, C_2. Note that the current flow for each half cycle (as indicated by the arrows) always passes through the meter in the same direction.

4-23. In this circuit, disregarding contact potential and assuming zero meter resistance, the circuit could be considered as a small resistance made up of D_1 and D_2, in series with one capacitor ($C_1 + C_2$) in series with R_f. Therefore, there will be a voltage across R_f proportional to the input signal.

4-24. In the actual 403B meter rectifier circuit, capacitors C17 and C18 provide a path for the AC feedback loop. The generator (Q3-Q6) with its large internal impedance (R_o) develops a voltage across the bridge. The meter is deflected according to the average value of the input voltage. The signal across R_f as in figure 4-6 provides negative feedback, resulting in extremely linear meter operation and large R_o.

4-25. POWER SUPPLY

4-26. The Model 403B operates on batteries only. This instrument uses four 6.5 volt nickel cadmium batteries and is designed to have a battery life of 40 hours before recharging.

4-27. R-39 has been adjusted at the factory for a charging rate of 11 ma to prolong battery life. If the instrument is used frequently in the field, R-39 can be adjusted for a charging rate of 20 ma.

CAUTION

If R-39 is adjusted to the 20 ma rate the instrument should be used on BATTERIES ONLY except when recharging batteries. Recharging of batteries is accomplished whenever the 403B is connected to an AC source. The battery life of the instrument can be prolonged at the 20 ma charging rate if the instrument is not continuously overcharged.

4-28. When the function switch is in the BATT TEST position, and the instrument indicates a battery voltage of 2.4 volts, recharge the batteries for 20 to 25 hours at the 20 ma rate to completely recharge the batteries in the instrument. A longer charging period (not to exceed 30 hours) will be required if the batteries have been allowed to discharge below 24 volts.

4-29. Figure 5-11 illustrates the battery charger, showing 5.5 ma of current flowing through the instrument and 5.5 ma of current through the batteries. R-39 is used to control the amount of current used to charge the batteries and caution must be used if R-39 is adjusted to maximum charging rate.

CAUTION

The four nickel-cadmium batteries in the hp 403B are in hermetically sealed containers. The user must be cognizant of temperature extremes while charging the batteries. Under high temperatures (above 50° Centigrade), hydrogen in the hermetically sealed battery container can build up large pressure causing damage to the batteries and/or instrument. DO NOT CHARGE BATTERIES ABOVE 40° Centigrade or 104° Fahrenheit, if R-39 is set above 11 ma charging rate.

4-30. Figure 5-11 illustrates a conventional power supply. For 115 volt operation the power transformer primaries are switched in parallel, and in series when used for 230 volt operation. The rectifier circuit is a conventional full wave bridge using C21 for a filter capacitor. Diode CR9 (7 volt breakdown diode) and Q7 make up the Constant Current Generator. The collector current of Q7 is equal to the voltage across CR9 divided by R37 and R39.

4-31. CR10 prevents the batteries from discharging to the charging circuit when the instrument is in the OFF position.

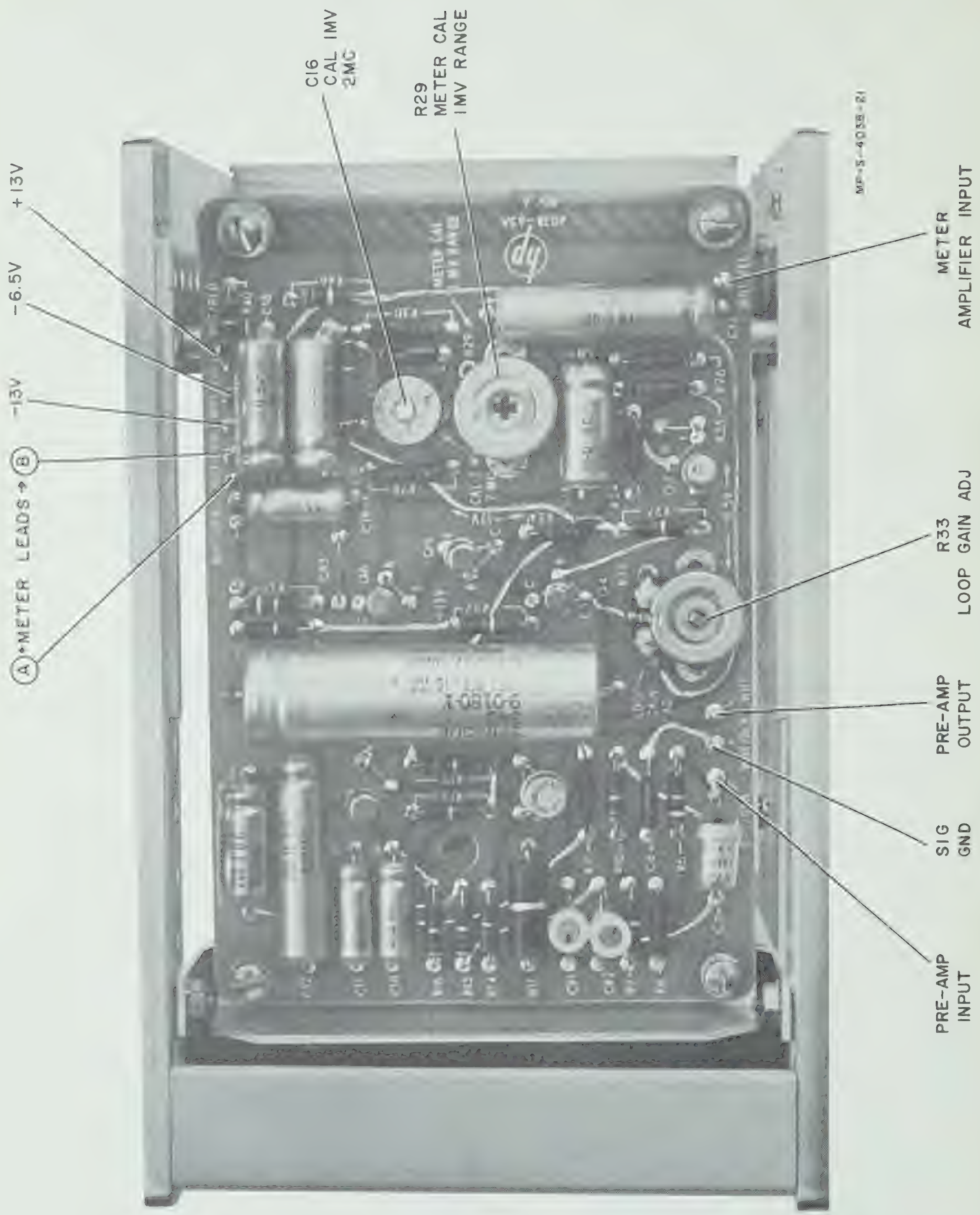


Figure 5-1. Model 403B Top View

SECTION V

MAINTENANCE

5-1. INTRODUCTION

5-2. This section contains test and maintenance information for your 403B. Included is a quick performance check that may be made with the instrument in its cabinet, as a part of routine maintenance or as a part of incoming quality control inspection.

5-3. This instrument should require very little maintenance. Should failure occur, however, a trouble shooting paragraph (5-10) has been included to assist in locating the failure.

5-4. Transistors, being inherently long lived devices, should not require replacement in the life of the instrument. If it becomes apparent, through systematic troubleshooting, that replacement is necessary, care should be taken not to damage the etched circuit board.

5-5. Errors may be introduced in the 403B because of the capacity added in the circuit after cabinet replacement. Therefore, after making gain or frequency response adjustments, temporarily place covers back on instrument and recheck the adjustment.

5-6. TEST INSTRUMENTS REQUIRED

5-7. Table 5-1 gives the test equipment required to check the 403B. An alternate method of checking the frequency response of the instrument with somewhat reduced accuracy and using less specialized equipment is given in paragraph 5-35.

Note

The ac voltmeter used in the procedure should have been recently calibrated and have a known flat response from 400 cps to at least 2 mc.

Table 5-1. Test Instruments Required

Instrument Type	Minimum Required Specifications	Recommended ⓗⓟ Instruments
DC Electronic Voltmeter	Sensitivity: 1 volt full scale minimum Input resistance: 10 megohms or higher	Model 412A Vacuum Tube Voltmeter
Voltmeter Calibration Generator	Output voltage range: .001 to 300 volts Signal frequency: 400 cps Distortion: less than 0.2%; Accuracy: ±0.25%	Model 738AR Voltmeter Calibrator
Frequency Response Test Oscillator	Output voltage: 3 volts into 50 ohms Frequency range: 300 kc to 10 mc Monitor meter accuracy: ±0.5%, 10 cps to 1 mc Other necessary features: 1) provision for use with external oscillator; 2) output step attenuator	Model 739AR Frequency Response Test Set
General Purpose Oscillator (low output impedance)	Frequency range: 5 cps to 600 kc Maximum output: 3 volts into 50 ohms Distortion: 0.5% below 500 kc	Model 200SR Oscillator
General Purpose Oscillator	Frequency range: 5 cps to 600 kc Maximum output: 20 volts open circuit Distortion: 0.5% below 500 kc	Model 200CD Wide Range Oscillator
Wide Range Oscillator	Frequency range: 10 cps to 10 mc Maximum output: 3 volts into 600 ohms Maximum distortion: 1% to 100 kc; 2% to 1 mc	Model 650A Test Oscillator
Low Frequency Oscillator	Frequency range: 1 cps to 10 cps Minimum output: 10 volts into 500 ohms Distortion: less than 1% Frequency response: flat within 0.2 db	Model 202A Low Frequency Function Generator
AC Electronic Voltmeter	Input impedance: 10 megohms shunted by 25 pf (below the 0.3 volt range) Accuracy: ±2% from 20 cps to 1 mc	Model 400D/H/L Vacuum Tube Voltmeter
Clip On DC Milliammeter	Current Range: 3 ma to 1 ampere Accuracy: ±3% ±0.1 ma	Model 428A/B DC Milliammeter

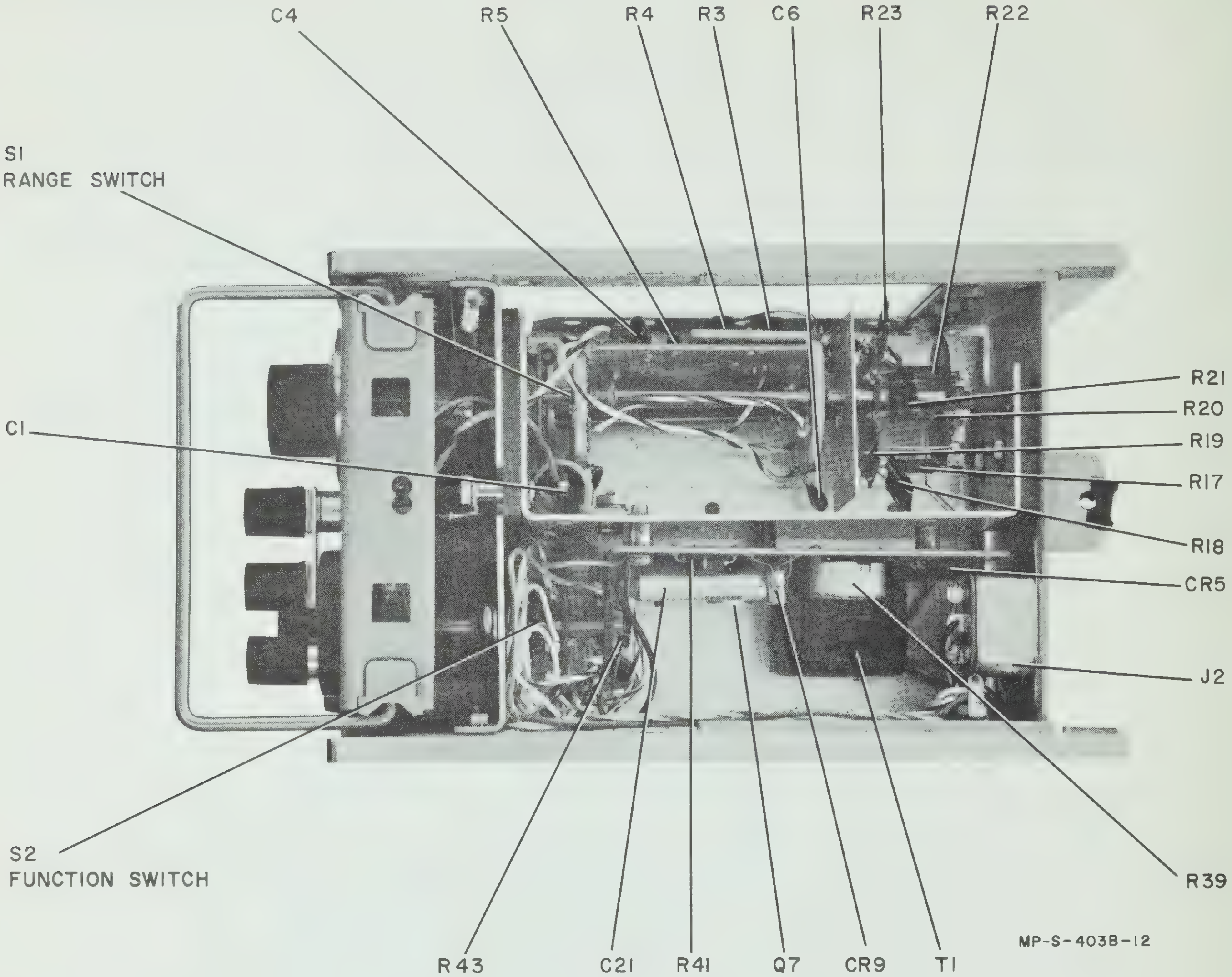


Figure 5-2. Model 403B Bottom View

5-8. MECHANICAL ZERO ADJUSTMENT

5-9. When the meter is properly zero-set the pointer rests over the zero calibration mark on the meter scale when the instrument is 1) at normal operating temperature, 2) in its normal operating position, and 3) turned off. Zero-set as follows to obtain best accuracy and mechanical stability:

a. Turn instrument off and allow 30 seconds for all capacitors to discharge.

b. Rotate mechanical zero-adjustment screw clockwise until the meter pointer is to the left of zero and moving to the right toward zero.

c. Continue to rotate adjustment screw clockwise; stop when pointer is right on zero. If the pointer overshoots zero, repeat steps c and d.

d. When the pointer is exactly on zero, rotate the adjustment screw approximately 15 degrees counter-clockwise. This is enough to free the adjustment screw from the meter suspension. If pointer moves during this step, repeat steps b through d.

5-10. TROUBLESHOOTING

5-11. To assist in troubleshooting, tables 5-2 and 5-3 are included in this section of the manual. Table 5-2, Troubleshooting, is used for evaluating problems that may be encountered and easily recognized by the operator, and therefore consists mainly of front-panel indications. Table 5-2 and 5-4, Test Procedure Troubleshooting, is for the technician to localize areas of trouble encountered while testing the Model 403B.

Note

When replacing any crystal diodes or transistors in the Model 403B, refer to paragraph 5-16 and Table 5-4.

Table 5-2. Troubleshooting

Symptom	Cause
No response to input	Fuse F1 blown Batteries low Shorted transistor CR1 or CR2 shorted Open contacts in range switch
Low reading on Batt. test	Recharge Batteries
Noisy indication on known quiet source	CR1 or CR2 noisy Noisy transistors (usually Q1 or Q2) CR3 or CR4
Meter pins when switching through ranges	Dirty contacts in range switch C7, C12, or C13 leaky
Meter pulsates at frequencies below 15 cps	C17, 18, 20 open or leaky
Meter calibration off on ranges above .03	Resistors or capacitors bad in range switch
Meter calibration off on ranges below .1	Resistors bad in intermediate attenuator Dirty contacts in range switch
Battery will not hold charge	CR10 shorted Shorted cell in battery
Battery charge inoperative	Q7, CR5, CR6, CR7, CR8 CR9, C21 Switch on 230V position when using 110V

Table 5-3. Test Procedure Troubleshooting

Symptom	Cause
R29 will not adjust for full scale indication	CR1, 2 CR3, 4 bad Q1 through Q6 bad
Noise (403B input terminated with a shielded 100K resistor)	Usually Q1 or Q2 noisy
Input resistance out of specs	Q1 or Q2 bad C9, C10, C11
Meter does not track properly	
1) Meter reads consistently above or below all meter divisions	CR3, CR4 bad R35 wrong value
2) Meter reads above some but below other divisions	Diodes CR3, CR4 bad Meter M1 bad
Low frequency response bad	CR1, 7, 12, 13, 18-20 or C31, 32 leaky
400D reads more than 1.5 volts on overload	CR1 or CR2 bad
Excessive Charging Rate R-39 No Effect	Bad CR9, Q7

5-12. REPAIR

5-13. CABINET REMOVAL.

a. Top Cover: remove the single screw which holds the cover to the rear panel and slide the cover toward the rear.

b. Bottom Cover: remove the flat head screw holding the cover to the rear panel and slide the cover toward the rear. The bail must be up.

c. Side Covers: remove the flat head screws which hold the cover to the side casting of the instrument.

5-14. SERVICING ETCHED CIRCUIT BOARDS.

5-15. Two single-sided and one double-sided circuit board are used in the Model 403B. When servicing this board, these general rules should be followed:

a. Do not apply excessive heat to the conductor or component being soldered.

b. Use a toothpick or wooden splinter to clean holes before inserting new components.

c. To remove a damaged component, clip leads near component; then apply heat and remove component lead with a straight upward motion.

d. To insure good connection between the eyelet and conductor, solder from the conductor side.

5-16. TRANSISTOR REPLACEMENT.

5-17. Transistors can be damaged by excessive heat. When replacing transistors on the Model 403B printed circuit board, follow the instructions given in paragraph 5-14. Refer to table 5-4 for any adjustments after replacement.

5-18. FUNCTION SWITCH REPAIR.

5-19. Figure 5-3 gives parts location and cabling detail on Model 403B FUNCTION switch.

5-20. FLUORESCENT INDICATOR DECAL.

5-21. If the FUNCTION switch is removed for any reason, the fluorescent indicator decal will have to be replaced. This decal has a special adhesive on the back that holds firmly against the FUNCTION switch nut. To assure positive contact, proceed as follows:

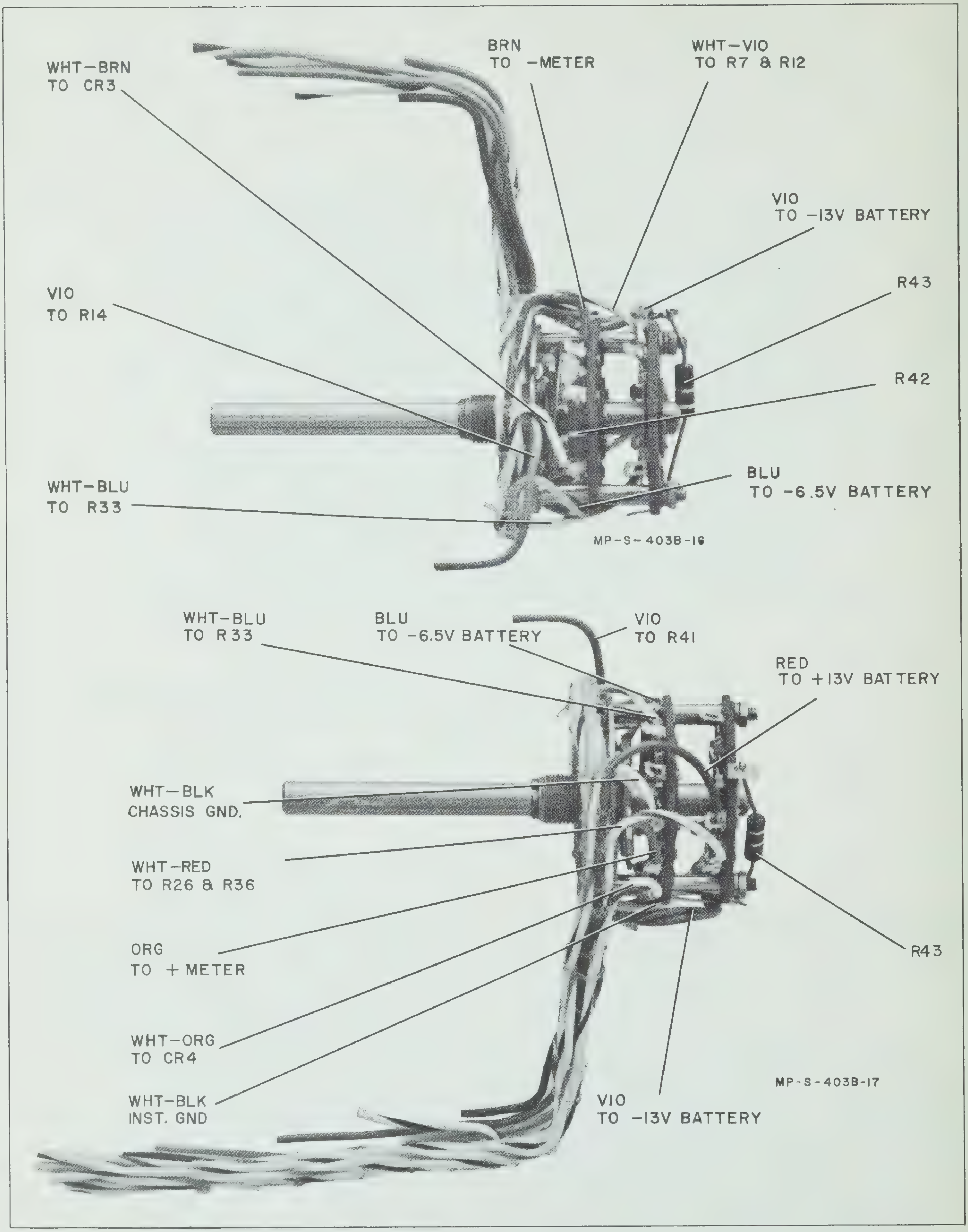


Figure 5-3. Function Switch Detail

1. Pilot light
2. Retainer clip
3. Heat shrinkable tubing
4. On-off knob
5. Special washer 3/8 inch OD x 0.26 inch ID
6. Florescent indicator decal
7. Sub-module half panel (meter)
8. Meter
9. Nut 1/2 inch
10. AC shield 403B-6D
11. Shield
12. Panel bushing
13. Nut 6-32 with external lock
14. On-off switch assembly
15. Screw 6-32 x 3/8 100° flat head philips drive
16. Screw 6-32 x 3/8 82° flat head slot drive
17. Cover 1/3 module 8 inch deep top
18. PC board 65A
19. Screw 6-32 x 1/2 binding head with lock
20. Battery holder
21. Screw 6-32 x 3/8 pan head
22. Battery holder
23. Rear panel, 1/3 module, 1/2 recess
24. Side frame 6 x 8 sub-module
25. Switch shield
26. Side cover 6 x 8 sub-module
27. Same as no. 15
28. Bottom cover 1/3 module 8 inch DP
29. Range switch assembly
30. Same as no. 15
31. Nut 6-32 SS
32. Washer split lock no. 6
33. Screw 6-32 x 3/8
34. Spacer no. 6 x 5/16
35. Washer flat 3/8
36. Washer no. 6 internal
37. Washer 3/8 internal
38. Lug solder
39. Tinnerman retainers
40. Nut 3/8
41. Nut 6-32 with lock
42. Coupler 1/4 inch ID
43. Nuts 10-28
44. Lugs solder no. 10
45. Washer no. 10 external-internal
46. Washer no. 10 internal
47. Insulator binding post double
48. Hinge
49. Bail
50. Foot
51. Range knob
52. Same as no. 47
53. Spacer binding post
54. Binding post
55. Meter trim
56. Batterys nickel cadmium
57. PC board 65C

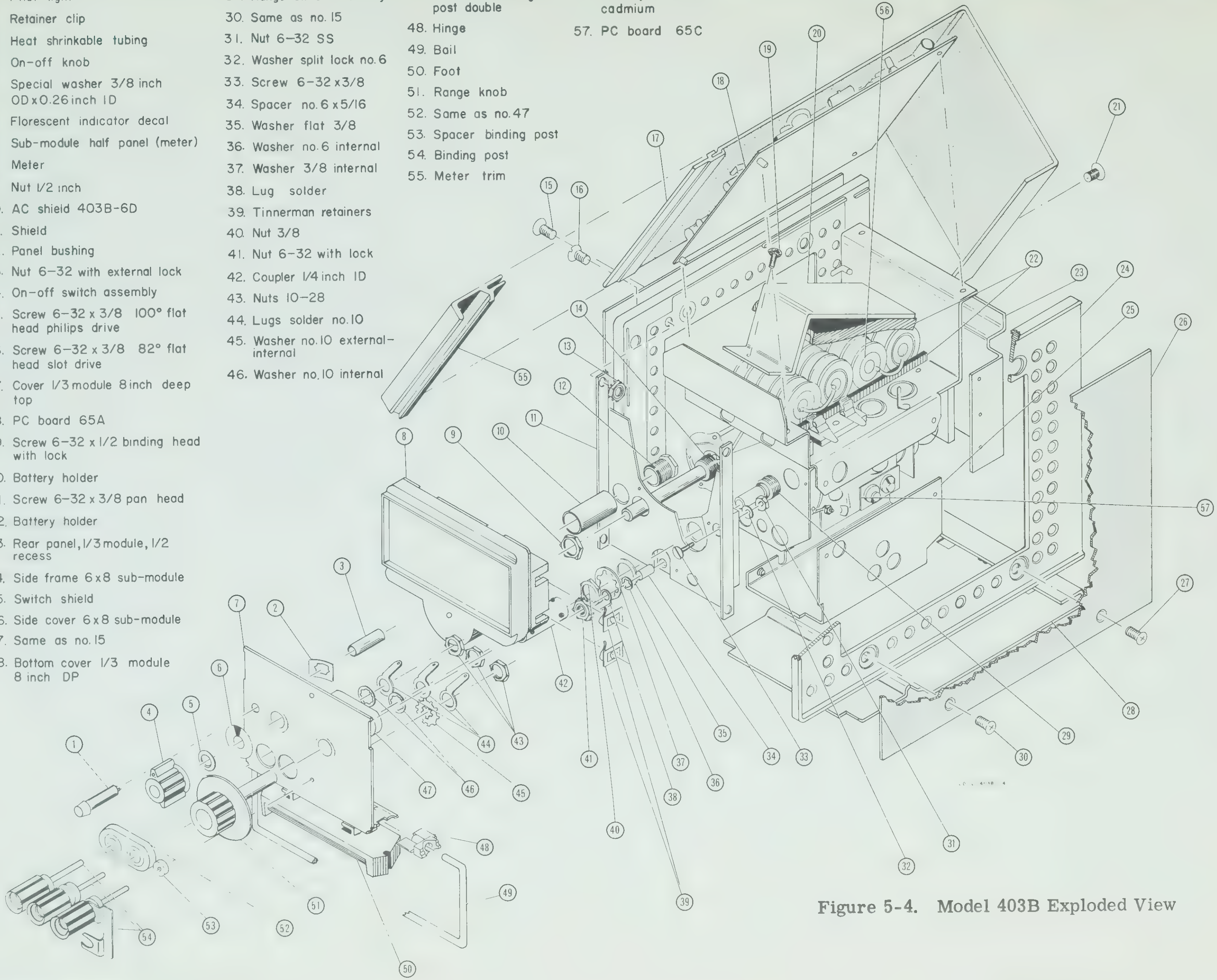


Figure 5-4. Model 403B Exploded View

Table 5-4. Transistor Replacement

Reference	Function	Checks or Adjustments Req.	Refer to Paragraph
Q1, 2	Q1 and Q2 work together to provide a high input impedance (Emitter Follower)	Check input impedance Readjust R29 Check noise	5-43 steps a thru d 5-30 steps c & d 5-26 steps a thru c
Q3, 4	Amplifier (Common emitter)	Readjust R33	5-31 steps a thru g
Q5	Amplifier (Common collector)	Readjust R33	5-31 steps a thru g
Q6	Amplifies signal (Common base)	Readjust R33	5-31 steps a thru g
CR1, 2	Protects Q1 from overload	Recheck overload characteristics Check noise	5-34 steps a thru c 5-26 steps a thru c
CR3, 4	Meter Diodes	Readjust R29 Readjust R45	5-30 steps c & d 5-29 steps c & d
CR5,	Rectifier Diodes	Check battery charge current	5-29 steps f & g
CR9	Zener Diode	Readjust R39	5-29 steps f & g
CR10	Isolation Diode	Check battery charge current	5-29 steps c & d
Q7	Charging Current Regulation	Readjust R39	5-29 steps f & g

a. Moisten the back of the decal with a piece of tissue soaked in xylene and allow a few minutes for the adhesive to soften.

b. Place the decal over the FUNCTION switch shaft, adhesive side down. Position the black area directly over the OFF line on the Model 403B panel and press the decal firmly against the FUNCTION switch nut.

c. Slide a bushing or nut over the shaft so that it will hold the decal in contact with the FUNCTION switch nut, and allow about 20 minutes for the adhesive to dry.

d. Remove the bushing or nut used for weighting and install the small spacer and FUNCTION switch knob.

5-22. ADJUSTMENTS

5-23. The following is a complete test and adjustment procedure and should be made only if it has been definitely determined that the Model 403B is out of adjustment. Transistor changes are usually not cause for complete adjustment (see table 5-4). If the instrument fails to make any one of the limits given in the following steps, carefully recheck your connections and procedure. If the instrument still fails the step, refer to tables 5-2 and 5-3 for possible cause and corrective action.

5-24. In order to avoid the effects of hand capacity, a tuning wand and tuning screwdriver with a plastic shank should be used for all adjustments.

Note

The 403B will meet the specifications called out in table 1-1 if the components of the 403B are functioning properly.

Throughout the following procedure the operator is asked to calibrate the 403B using 0. 9 full scale indication on the 403B meter face. This procedure is used instead of full scale indication, to obtain greater resolution when determining error in the positive direction of the 403B meter face. If full scale deflection on the 403B is used, the error has to be interpolated in the positive direction, reducing the accuracy of the overall calibration.

5-25. PRELIMINARY.

a. Turn the 403B FUNCTION switch to BATT. TEST. Meter on 403B should read 2. 4 volts or above as read on the 3. 0 volt scale.

b. If the 403B does not read 2. 4 volts, recharge batteries until batteries are up to normal.

5-26. NOISE CHECK.

a. Turn the FUNCTION switch to ON.

b. Terminate the 403B INPUT in 100K ohms. A dual banana plug of 3/4 inch spacing with shield, that will completely shield the INPUT terminals, should be used. The reading on the 403B should be less than 4% of full scale on the . 001 volt range, and less than 3% of full scale on the . 3 volt range.

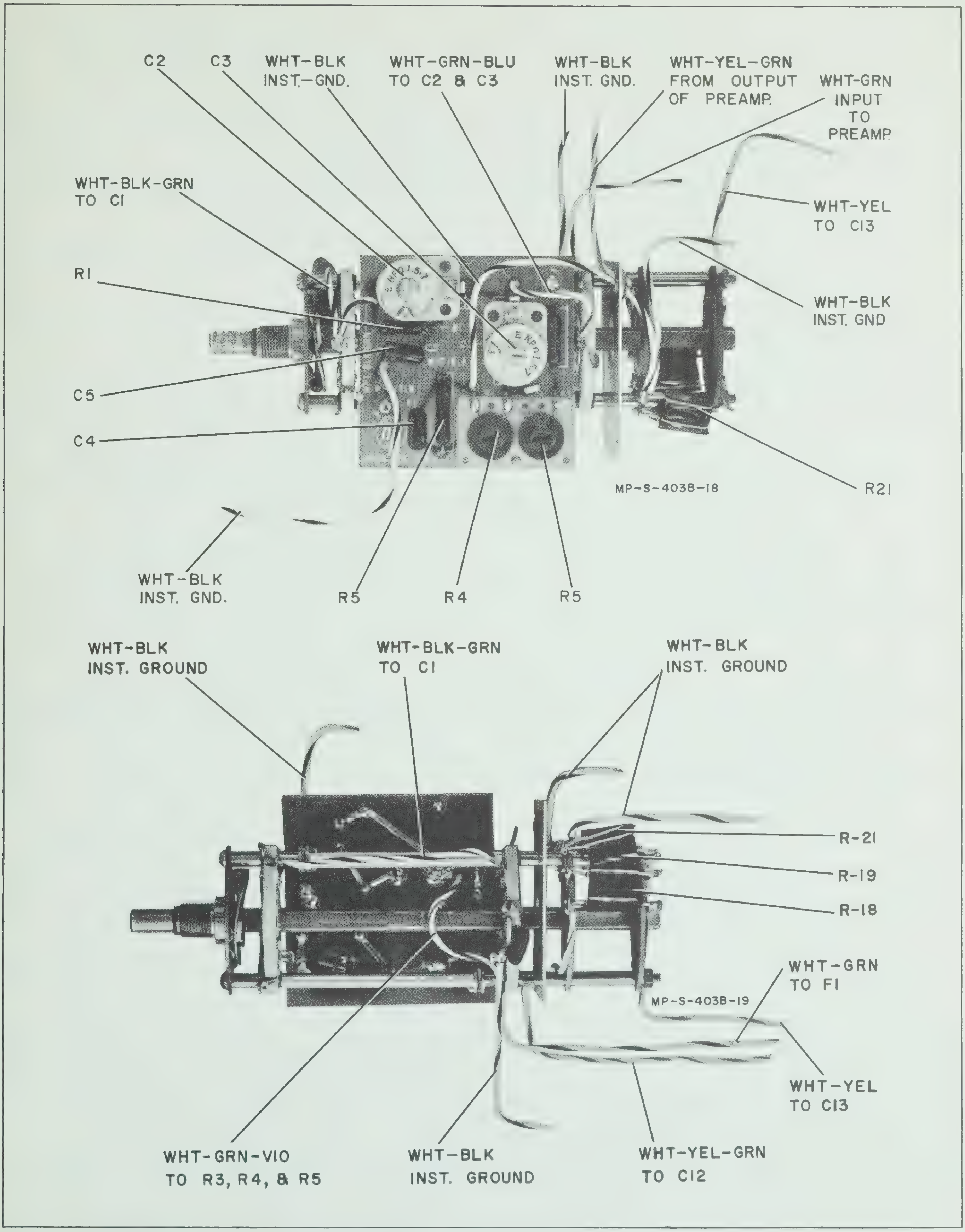


Figure 5-5. Range Switch Details

c. Let the instrument warm up for at least three minutes, then switch the RANGE switch through all ranges in either direction. The meter on the 403B should not pin.

5-27. INPUT RESISTANCE

5-28. Check the Model 403B input resistance by following the instruction outlines in paragraph 5-43.

5-29. POWER SUPPLY

a. Remove Bottom Cover from 403B Cabinet.

b. Turn Function switch on 403B to BATT. TEST position.

c. Using a 412A DC Voltmeter, connect the negative lead to the violet wire going to the 403B battery and the positive lead to the red wire going to the battery.

d. Adjust R45 until meter on instrument under test reads the same value read on the 412A.

CAUTION

DC voltmeter must be isolated from 403B ground.

Note

If voltage reading on ⓗ 412A does not indicate 24 volts or above, recharge the batteries in the 403B.

e. Insert Power Cord on the ⓗ 403B into a variable autotransformer and adjust the autotransformer to 115 volts. Turn the function switch on the ⓗ 403B to ON.

f. Connect the probe from the ⓗ 428A or B around the purple wire located in the upper right hand side of the charging board.

g. Adjust R39 for 11 ma indication on ⓗ 428A/B.

Note

If indication on 428A/B is negative in direction, reverse probe.

h. Vary input line voltage with autotransformer from 102 to 128 volts and verify indication on ⓗ 428 A/B does not vary from 11 ma ±.5 ma.

i. Connect an ⓗ 400D or H or L across the red and violet wires connecting to the batteries. The ripple shall not exceed 1 millivolt.

5-30. TRACKING AND CALIBRATION

a. Connect an ⓗ 738AR VOLTMETER CALIBRATOR to an ⓗ 403B, as shown in figure 5-10. The 200K resistor is used for input resistance check. Refer to paragraph 5-43.

b. Rotate the 403B RANGE switch to .001 volt position.

c. Set the ⓗ 738AR to .001 volt 400 cycles RMS.

d. ⓗ 403B will read exactly .001 volt. If not adjust R29 for full scale indication.

e. Set the 403B RANGE switch to .1 volt position and the voltmeter calibrator (738AR) to .1 volt at 400 cycles.

f. Adjust R3 for full scale indication on the .1 volt range of the ⓗ 403B.

g. Set the 403B RANGE switch to 30 volt position the voltmeter calibrator (738AR) to 30 volts at 400 cycles.

h. Adjust R4 for full scale indication on the 10 volt range of the ⓗ 403B.

i. Check the 403B full scale calibration on all ranges alternately adjusting the MULTIPLIER and RANGE switches on the 738AR and RANGE switch on the 403B (i.e.: .001V - .003V, etc.). Accuracy should be within ±0.5% of full scale on all ranges.

j. Switch the 738AR FUNCTION switch to 1 volt TRACKING.

k. Turn the 403B RANGE switch to 1 volt.

l. Check the 403B meter tracking at 0.1 volt increments. Variation should be less than ±1% of full scale.

5-31. FREQUENCY RESPONSE

a. Connect an ⓗ 200SR Oscillator to an ⓗ 739 AR FREQUENCY RESPONSE TEST SET, as shown in figure 5-6.

b. Disconnect ⓗ 403B from ⓗ 738AR and connect as shown in figure 5-6.

c. Set the ⓗ 739AR RANGE SELECTOR to EXTERNAL and adjust the 200SR Oscillator to 400 cycles.

d. Adjust AMPLITUDE control on ⓗ 200SR until the ⓗ 403B reads exactly 0.9 full scale at .001 volt range.

e. Adjust the METER SET (739AR) control until the meter on the ⓗ 739AR is at the SET LEVEL position. (This is a reference).

f. Adjust RANGE SELECTORS AND FREQ Tuning on the ⓗ 739AR for a 300KC output. Adjust the 739AR Amplitude control slightly (if needed) to bring reference meter indication to set level.

g. Rotate tuning knob on ⓗ 739AR between 300KC and 1 mc and adjust R33 (if necessary) for a flat response. 403B meter shall remain at .9 mv ±1 div.

Note

Repeat step (c) if R33 has been adjusted and adjust R29 until 403B reads exactly .9 of full scale. Repeat step (g).

h. Position RANGE SELECTOR on hp 739AR to 1-3 mc Range, rotating tuning knob between 1 mc and 3 mc, adjusting C-16 until response is flat between 1-2 mc with a gradual rolloff between 2 and 3 mc.

i. Rotate 403B Range to 0.1 volt position.

j. Rotate OUTPUT attenuator on hp 739AR to .1 volt position and rotate RANGE SELECTOR to the 300 kc to 1 mc position, adjusting frequency to 300 kc.

k. Adjust C2 until 403B reads exactly .9 of full scale.

l. Check the 403B on all ranges from 1 mv to 3 volts at 1 mc and 2 mc with the 739AR. Verify 403B reads .9 of full scale ±1 division.

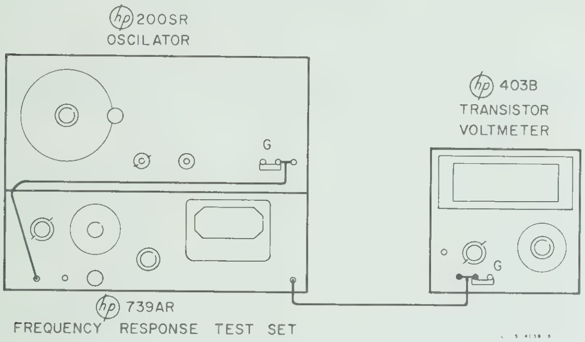


Figure 5-6. Frequency Response Setup

5-32. LOW FREQUENCY RESPONSE.

a. Connect an hp Model 202A LOW FREQUENCY FUNCTION Generator, terminated with a 5000-ohm 1/2-watt resistor, to the 403B as shown in figure 5-7.

Note

Do not set the 202A Amplitude control above 30.

b. Set the Model 202A FUNCTION switch to SINE. Adjust RANGE and FREQUENCY controls to 400 cps.

c. Adjust the Model 202A AMPLITUDE control for a reference at 0.9 of full scale on the 0.001 volt range of the 403B. Note this reading.

d. Without changing the output amplitude of the 202A, adjust the 202A RANGE and FUNCTION selector for a 10 cps output.

e. The 403B should read ±5% of full scale as compared with the 400 cps reference.

f. Without changing the output amplitude of the Model 202A, adjust the 202A RANGE and FUNCTION selector for a 5 cps output.

g. The 403B should read ±5% of full scale as compared with the 400 cps reference.

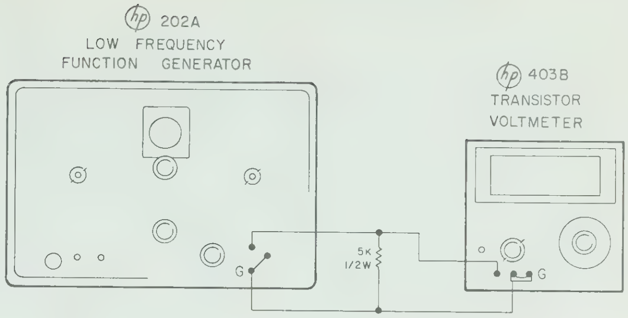


Figure 5-7. Low Frequency Response Setup

5-33. 30-VOLT RESPONSE.

a. Rotate the RANGE switch on the 403B to the 30 volt Range.

b. Set a 200CD WIDE RANGE OSCILLATOR to 20 volts at 400 cps, and connect it to an hp 400D/H/L. Connect the INPUT of the 403B to the INPUT of the hp 400D/H/L.

c. Adjust the hp 200CD Amplitude control for a convenient reading on the 403B. Note the reading on the 400D/H/L.

d. Adjust the 200CD output to 300 kc. Adjust the 200CD AMPLITUDE until the 400D/H/L indicates the same value as noted in paragraph 5-33, step c.

e. Verify the 403B meter reading at 200 kc is the same as that at 400 cps.

5-34. OVERLOAD CHECK.

a. Turn the 403B off and connect the 400D/H/L between the base of Q1 and the chassis.

b. Connect the 738AR, with OUTPUT SELECTOR set to OFF, to the 403B through a 15K, 10-watt resistor as shown in figure 5-8.

c. Turn the OUTPUT SELECTOR to 400 cps rms, and the MULTIPLIER and RANGE switch to 300 volts. With the 403B set to any of its five lower ranges (.001-.03) the reading on the 400D should be less than 1.5 volts.

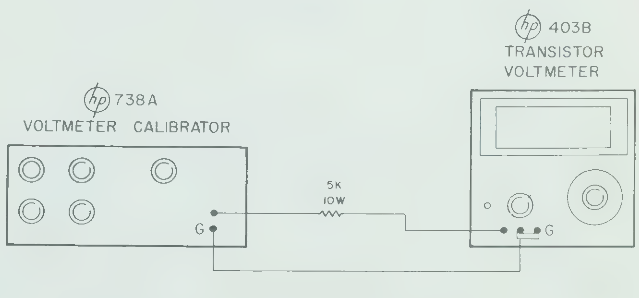


Figure 5-8. Overload Check Setup

5-35. ALTERNATE METHOD OF ADJUSTING FREQUENCY RESPONSE.

5-36. The following is a frequency response adjustment procedure using less specialized equipment. The instruments should be set up as shown in figure 5-9. This procedure will result in slightly reduced accuracy as compared to paragraphs 5-25 through 5-34, but is sufficient to return the performance of the instrument to within its published specifications.

Note

The 400D/H/L used in this procedure should have been recently calibrated and have a known frequency response from 400 cps to at least 2 mc. If there is a variation in response between 400 cps and 2 mc, this should be compensated for when adjusting the 403B.

a. Rotate the 403B RANGE switch to .001 volt position.

b. Using the 400D/H/L set the 650A output at .001 volt 400 cps and connect it to the 403B. Note the 403B reading.

c. Adjust the 650A output for .001 volt at 2 mc, as indicated on the 400D/H/L.

d. Adjust R33 on the 403B until the reading at 2 mc is the same as it was at 400 cycles.

e. Rotate frequency tuning knob on 650A between 300 kc and 2 mc, adjusting C16 in the 403B for a flat response up to 2 mc with a gradual roll off between 2 and 3 mc.

f. Rotate 403B RANGE switch to .1 volt position.

g. Adjust the 650A output for .1 volt at 1 mc as indicated on the hp 400D/H/L.

h. Adjust C2 in the 403B until the 403B meter indicates exactly full scale.

i. For 30 volt response checks follow procedure in paragraph 5-30 steps g through h substituting the 650A in place of the 738AR.

j. For low frequency response checks follow procedure in paragraph 5-32 substituting the 650A in place of the 202A. (650A can be used only to 10 cps.)

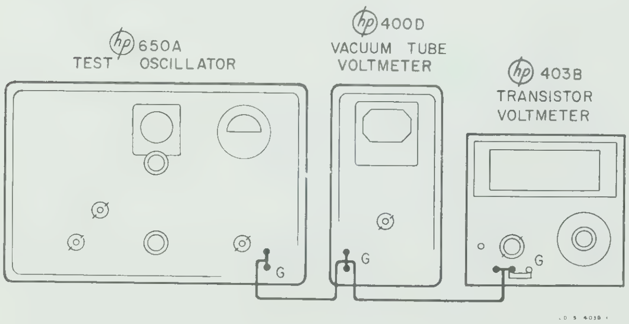


Figure 5-9. Alternate Frequency Response Setup

5-37. PERFORMANCE CHECK

5-38. The following procedure is to verify proper operation. A complete adjustment and test procedure is given in paragraph 5-29.

Note

For a complete performance check to verify specifications, proceed to paragraph 5-39, and follow all steps and note indications, but no adjustments should be made. The specifications to be met are listed in the front of the manual.

5-39. CALIBRATION

a. Turn the 403B FUNCTION switch to BATT TEST. Meter should read 2.4 volts as read on the 3.0 volt scale.

b. Set RANGE to 300 VOLTS; FUNCTION to ON.

c. Turn the 738AR POWER switch ON; set OUTPUT SELECTOR to OFF and allow the 738AR to warm up for 1/2 hour.

d. Connect the 738AR and 403B as shown in figure 5-10.

WARNING

The 738AR is a constant voltage source. Potentials can be present at the output terminals which could be hazardous to human life. Be careful not to touch the output leads without first turning OUTPUT SELECTOR to OFF.

e. Alternately adjust MULTIPLIER and RANGE on the 738AR and RANGE on the 403B to check the 403B on each range down to the .001 volt range. The 403B should read within ±2% of full scale on every range. (Use Calibration Table 5-5 for reference).

Table 5-5. Calibration Table

Model 403B RANGE	Model 738AR MULTIPLIER	Model 738AR RANGE	Model 403B Reading	Tolerance + Volts
300	100	3	300	6
100	100	1	100	2
30	10	3	30	0.6
10	10	1	10	0.2
3	1	3	3	0.06
1	1	1	1	0.02
.3	.1	3	0.3	6 mv
.1	.1	1	0.1	2 mv
.03	.01	3	0.03	0.6 mv
.01	.01	1	0.01	0.2 mv
.003	.001	3	3 mv	0.06 mv
.001	.001	1	1 mv	0.02 mv

5-40. FREQUENCY RESPONSE.

5-41. Test for response to 500 kc, 1 mc and 2 mc.

a. Connect -hp- Model 200SR Oscillator to the -hp- Model 739AR Frequency Response Test Set as shown in figure 5-6.

b. Turn Model 739AR RANGE SELECTOR to EXTERNAL position, and adjust the Model 200SR Oscillator to 400 cps.

c. Turn OUTPUT ATTENUATOR (V. T. V. M. SCALE) on the Model 739AR to the . 01 range.

d. Turn the Model 403B RANGE switch to .01 volt.

e. Adjust Model 200SR AMPLITUDE control for a reference of .9 of full scale on the .01 VOLTS RANGE of the Model 403B.

f. Set Model 739AR meter to SET LEVEL with the METER SET control.

g. Adjust the RANGE SELECTOR and FREQ. TUNING on Model 739AR for 500 kc. Set Model 739AR to SET LEVEL with the oscillator AMPLITUDE control. Model 403B should read . 9 of full scale ±0. 18 mv (±2%).

h. Adjust the RANGE SELECTOR and FREQ TUNING on Model 739AR for 500 kc. Set Model 739AR to SET LEVEL with the oscillator AMPLITUDE control. The Model 403B should read . 9 of full scale ±0. 45 mv (±5%).

5-42. LOW FREQUENCY RESPONSE.

a. Connect -hp- Model 202A Low FREQUENCY FUNCTION GENERATOR, terminated with a 600 ohm load, to the Model 403B as shown in figure 5-7.

Note

DO NOT set the Model 202A output voltage above . 2 volts.

b. Set the Model 202A FUNCTION switch to SINE. Adjust RANGE and FREQUENCY controls to 400 cps.

c. Adjust the Model 202A AMPLITUDE control for a reference of . 9 of full scale on . 01 VOLTS RANGE of the Model 403B.

d. Without changing the output AMPLITUDE of the Model 202A, adjust Model 202A RANGE and FREQUENCY for a 10 cps output.

e. The Model 403B should read . 9 of full scale ±0. 18 mv (±2%).

f. Without changing the output AMPLITUDE of the Model 202A, adjust Model 202A RANGE and FREQUENCY for a 5 cps output.

g. The Model 403B should read . 9 of full scale ±0. 45 mv (±5%).

5-43. INPUT RESISTANCE.

a. Turn the Model 403B RANGE switch to . 1 volt position.

b. Adjust MULTIPLIER and RANGE switch on the Model 738AR for an output of 0. 1 volt.

c. Move the input from the Model 738AR to point B (figure 5-10). Note the Model 403B reading (E_o).

d. Calculate the Model 403B input resistance using the following formula:

$$R_{input} = \frac{E_o}{0.1 - E_o} \times 200,000 \text{ ohms}$$

The input resistance should fall between 1. 5 and 2. 5 megohms.

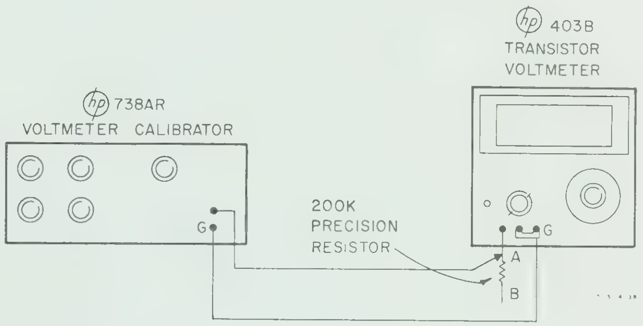
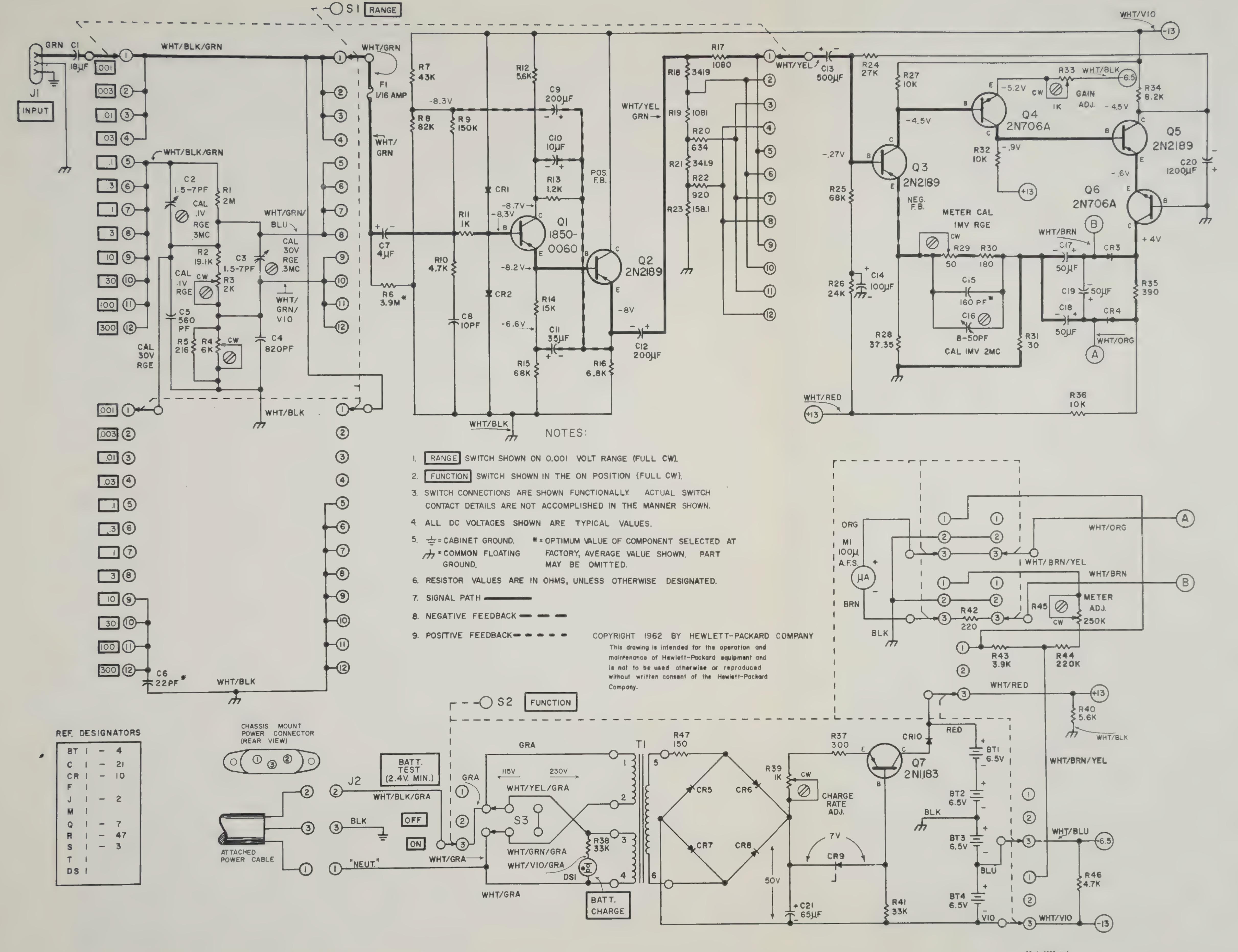


Figure 5-10. Performance Check Setup



NOTES:

1. RANGE SWITCH SHOWN ON 0.001 VOLT RANGE (FULL CW).
2. FUNCTION SWITCH SHOWN IN THE ON POSITION (FULL CW).
3. SWITCH CONNECTIONS ARE SHOWN FUNCTIONALLY. ACTUAL SWITCH CONTACT DETAILS ARE NOT ACCOMPLISHED IN THE MANNER SHOWN.
4. ALL DC VOLTAGES SHOWN ARE TYPICAL VALUES.
5. = CABINET GROUND. = COMMON FLOATING GROUND. * = OPTIMUM VALUE OF COMPONENT SELECTED AT FACTORY, AVERAGE VALUE SHOWN. PART MAY BE OMITTED.
6. RESISTOR VALUES ARE IN OHMS, UNLESS OTHERWISE DESIGNATED.
7. SIGNAL PATH
8. NEGATIVE FEEDBACK
9. POSITIVE FEEDBACK

REF. DESIGNATORS

BT	1	4
C	1	21
CR	1	10
F	1	
J	1	2
M	1	
Q	1	7
R	1	47
S	1	3
T	1	
DS	1	

Figure 5-11. Schematic Diagram

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION

6-2. This section contains information for ordering replacement parts. Table 6-1 lists parts in alpha-numerical order of their reference designators and indicates the description and ⓗⓟ stock number of each part, together with any applicable notes. Table 6-2 lists parts in alpha-numerical order of their ⓗⓟ stock numbers and provides the following information on each part:

a. Description of the part (see list of abbreviations below).

b. Typical manufacturer of the part in a five-digit code; see list of manufacturers in appendix.

c. Manufacturer's stock number.

d. Total quantity used in the instrument (TQ column)

e. Recommended spare part quantity for complete maintenance during one year of isolated service (RS column).

6-3. Miscellaneous parts not indexed in table 6-1 are listed at the end of table 6-2.

6-4. ORDERING INFORMATION

6-5. To order a replacement part, address order or inquiry either to your authorized Hewlett-Packard sales representative or to

CUSTOMER SERVICE
Hewlett-Packard Company
395 Page Mill Road
Palo Alto, California

or, in Western Europe, to

Hewlett-Packard S. A.
Rue du Vieux Billard No. 1
Geneva, Switzerland.

6-6. Specify the following information for each part:

a. Model and complete serial number of instrument.

b. Hewlett-Packard stock number.

c. Circuit reference designator

d. Description

6-7. To order a part not listed in tables 6-1 and 6-2, give a complete description of the part and include its function and location.

REFERENCE DESIGNATORS

A = assembly	F = fuse	P = plug	V = vacuum tube, neon bulb, photocell, etc.
B = motor	FL = filter	Q = transistor	W = cable
C = capacitor	J = jack	R = resistor	X = socket
CR = diode	K = relay	RT = thermistor	XF = fuseholder
DL = delay line	L = inductor	S = switch	XDS = lampholder
DS = device signaling (lamp)	M = meter	T = transformer	Z = network
E = misc electronic part	MP = mechanical part		

ABBREVIATIONS

a = amperes
bp = bandpass
bwo = backward wave oscillator
c = carbon
cer = ceramic
cmo = cabinet mount only
coef = coefficient
com = common
comp = composition
conn = connection
crt = cathode-ray tube
dep = deposited
EIA = Tubes or transistors meeting Electronic Industries' Association standards will normally result in instrument operating within specifications; tubes and transistors selected for best performance will be supplied if ordered by ⓗⓟ stock numbers.

elect = electrolytic
encap = encapsulated
f = farads
fxd = fixed
Ge = germanium
grd = ground (ed)
h = henries
Hg = mercury
impg = impregnated
incd = incandescent
ins = insulation (ed)
K = kilo = 1000
lin = linear taper
log = logarithmic taper
m = milli = 10^{-3}
M = megohms
ma = milliamperes
μ = micro = 10^{-6}
minat = miniature
mfgl = metal film on glass
mfr = manufacturer

mtg = mounting
my = mylar
NC = normally closed
Ne = neon
NO = normally open
NPO = negative positive zero (zero temperature coefficient)
nsr = not separately replaceable
obd = order by description
p = peak
pc = printed circuit board
pf = picofarads = 10^{-12} farads
pp = peak to peak
piv = peak inverse voltage
pos = position (s)
poly = polystyrene
pot = potentiometer
rect = rectifier

rot = rotary
rms = root-mean-square
rmo = rack mount only
s-b = slow-blow
Se = selenium
sect = section(s)
Si = silicon
sil = silver
sl = slide
td = time delay
TiO_2 = titanium dioxide
tog = toggle
tol = tolerance
trim = trimmer
twt = traveling wave tube
var = variable
w/ = with
W = watts
ww = wirewound
w/o = without
* = optimum value selected at factory, average value shown (part may be omitted)

Table 6-1. Reference Designation Index

Circuit Reference	(hp) Stock No.	Description #	Note
A1	403B-65A	Assy, printed circuit: includes, C7 thru C20 Q1 thru Q6 CR1 thru CR4 R6 thru R16 R24 thru R36 R40 R46	
A2	403B-65B	Assy, resistor board: includes, CR21 R1 thru R4 CR5 thru CR10 R37 thru R41 T1 R44 Q7 R45	
A3	403B-65C	Assy, resistor board: includes, C2 thru C5 R1 thru R4	
BT1, 2, 3, 4	1420-0015	Battery, Nickel Cadmium, 6 V nom. 225 mah	
C1	0170-0033	C: fxd, 0.18 μf ±10%, 600 vdcw	
C2 thru C3	0130-0003	C: var, cer, 1.5-7 pf ±10%, 500 vdcw	
C4	0140-0151	C: fxd, mica, 820 pf ±2%, 300 vdcw	
C5	0140-0178	C: fxd, mica, 560 pf ±2%, 300 vdcw	
C6	0140-0145	C: fxd, mica, 15 pf ±5%, 500 vdcw	
C7	0180-0008	C: fxd, elect., 4.0 μf -15% +20%, 60 vdcw	
C8	0160-0205	C: fxd, mica, 10 pf ±5%, 500 vdcw	
C9	0180-0060	C: fxd, elect., 200 μf -10% +100%, 3 vdcw	
C10	0180-0059	C: fxd, elect., 10 μf, 10 vdcw	
C11	0180-0064	C: fxd, elect., 35 μf -10% +100%, 6 vdcw	
C12	0180-0104	C: fxd, elect., 200 μf, 15 vdcw	
C13	0180-0063	C: fxd, elect., 500 μf -10% +100%, 3 vdcw	
C14	0180-0039	C: fxd, elect., 100 μf, 12 vdcw	
C15	0140-0218	C: fxd, mica, 160 pf ±2%, 300 vdcw	
C16	0130-0017	C: var, cer, 8-50 pf, 500 vdcw	
C17, 18	0180-0058	C: fxd, elect., 50 μf -10% +100%, 25 vdcw	
C19	0180-0033	C: fxd, elect., 50 μf, 6 vdcw	
C20	0180-0150	C: fxd, elect., 1200 μf, 10 vdcw	
C21	0180-0149	C: fxd, elect., 65 μf, 60 vdcw	
CR1, CR2	G-29M-7	Diode, Silicon	
CR3, CR4	1901-0027	Diode, Silicon, HD5004	
CR5, 6, 7, 8, 10	1901-0025	Diode, Silicon, 50 ma, 100 piv	
CR9	G-29A-74	Diode, Breakdown	
F1	1400-0011	Fuse, Beryllium Copper, 1/16 Amp	
Q1	1850-0060	Transistor PNP	
Q2, 3, 5	1850-0096	Transistor, PNP, 2N2189	
Q4, 6	1854-0017	Transistor, NPN, 2N706A	
Q7	1850-0064	Transistor, PNP, 2N1183	
R1	0727-0287	R: fxd, comp, 2 Meg ±1%, 1/2W	

See introduction to this section.

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	ⓗ Stock No.	Description #	Note
R2	0727-0443	R: fxd, comp, 19.1K ±1%, 1/2W	
R3, R4	2100-0390	R: var, 2K and 6K ohms, 1 1/4W	
R5	0727-0056	R: fxd, mfgl, 216 ohm, ±1/2%, 1/2W	
R6	0687-3951	R: fxd, comp, 3.9M ±10%, 1/2W	
R7	0758-0051	R: fxd, comp, 43K ±5%, 1/2W	
R8	0758-0022	R: fxd, comp, 82K ±5%, 1/2W	
R9	0687-1541	R: fxd, comp, 150K ±10%, 1/2W	
R10	0687-4721	R: fxd, comp, 4.7K ±10%, 1/2W	
R11	0693-1021	R: fxd, comp, 1K ±10%, 2W	
R12	0687-5621	R: fxd, comp, 5.6K ±10%, 1/2W	
R13	0687-1221	R: fxd, comp, 1.2K ±10%, 1/2W	
R14	0687-1531	R: fxd, comp, 15K ±10%, 1/2W	
R15	0687-6831	R: fxd, comp, 68K ±10%, 1/2W	
R16	0687-6821	R: fxd, comp, 6.8K ±10%, 1/2W	
R17	0727-0103	R: fxd, mfgl, 1.08K ±1%, 1/2W	
R18	403B-26A	R: fxd, WW, 3.41K ±.2%, 1/2W	
R19	403B-26B	R: fxd, WW, 1.081K ±.2%, 1/2W	
R20	0727-0084	R: fxd, mfgl, 634 ohms ±1%, 1/2W	
R21	403B-26C	R: fxd, WW, 341.9 ohms ±.2%, 1/2W	
R22	0727-0096	R: fxd, mfgl, 920 ohms, ±1%, 1/2W	
R23	403B-26D	R: fxd, WW, 158.1 ohms ±.2%, 1/2W	
R24	0758-0074	R: fxd, mfgl, 27K ±2%, 1/2W	
R25	0758-0076	R: fxd, mfgl, 68K ±2%, 1/2W	
R26	0758-0073	R: fxd, mfgl, 24K ±2%, 1/2W	
R27	0687-1031	R: fxd, comp, 10K ±10%, 1/2W	
R28	0727-0017	R: fxd, mfgl, 37.35 ohm ±1/2%, 1/2W	
R29	2100-0240	R: var, WW, 50 ohms ±20%, 1W	
R30	0727-0050	R: fxd, mfgl, 180 ohms ±1%, 1/2W	
R31	403A-26G	R: fxd, WW, 30 ohms	
R32	0687-1031	R: fxd, comp, 10K ±10%, 1/2W	
R33	2100-0154	R: var, comp, 1K ±30%, 3/10 W	
R34	0758-0048	R: fxd, mfgl, 8.2K ±2%, 1/2W	
R35	0758-0048	R: fxd, comp, 390 ohms ±10%, 1/2W	
R36	0687-1031	R: fxd, comp, 10K ±10%, 1/2W	
R37	0686-3015	R: fxd, comp, 348 ohms ±5%, 1/2W	
R38	0687-3331	R: fxd, comp, 33K ±10%, 1/2W	
R39	2100-0391	R: var, WW, 1K ±20%, 1.25W	
R40	0687-5621	R: fxd, comp, 5.6K ±10%, 1/2W	
R41	0687-3331	R: fxd, comp, 33K ±10%, 1/2W	
R42	0687-2211	R: fxd, comp, 1.5K ±10%, 1/2W	
R43	0687-3921	R: fxd, comp, 3.9K ±10%, 1/2W	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	hp Stock No.	Description #	Note
R44	0687-2241	R: fxd, comp, 220K ±10%, 1/2 W	
R45	2100-0144	R: var, comp, 250K ±30%, .2 W	
R46	0687-4721	R: fxd, comp, 4.7K ±10%, 1/2 W	
R47	0758-0007	R: fxd, mfgl, 150 ohm ±5%, 1/2 W	
S1	403B-19W	Assy, RANGE Switch, 3 sect, 12 pos., includes: C2 thru C6	
S2	403B-19A	Assy, FUNCTION Switch, 2 sect, 3 pos., includes: R42 and R43	
S3	3101-0033	Switch - Slide: DPDT 115-230V	
T1	9100-0172	Transformer	
		MISCELLANEOUS	
	7123-0101	Washer, fluorescent indicator for use with Function Switch Knob	
J1	G-83A-1	Insulator, B. P. Double Keyed	
	G-76K	Assy, Binding Post: Black w/strap	
	G-10	Assy, Binding Post: Red	
	G-10F	Assy, Binding Post: Black	
M1	403B-81A	Meter	
	1400-0008	Holder Fuse, 1/2" wide, 3/16" thick, 1-5/8" long.	
DS1	1450-0048	Indicator, Neon	
F1	2110-0011	Fuse, 1/16 amp, 250 v maximum, 5.4 ohm	
	8120-0078	Cord, Power	
	403B-901	Operating & Service Manual	

See introduction to this section

Table 6-2. Replaceable Parts

ⓗ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
G-10E	Binding Post: red	28480	G-10	1	1		
G-10F	Binding Post: black	28480	G-10F	1	1		
G-29A-74	Diode, Si	28480	G-29A-74	2	2		
G-29M-7	Diode, Si	28480	G-29M-7	1	1		
G-76K	Assy, binding post: black w/strap	28480	G-76K	1	1		
G-83A-1	Insulator, binding post: dbl keyed	28480	G-83A-1	1	1		
403A-26G	R: fxd, WW, 2 sect, 30 ohms	28480	403A-26G	1	1		
403B-19A	Assy, FUNCTION Switch: 2 sect, 3 pos, includes, R42 and R43	28480	403B-19A	1	1		
403B-19W	Assy, RANGE Switch: 3 sect, 12 pos, includes, C2 thru C6	28480	403B-19W	1	1		
403B-26A	R: fxd, WW, 341K ±. 2%, 1/2W	28480	403B-26A	1	1		
403B-26B	R: fxd, WW, 1. 081K ±2%, 1/2W	28480	403B-26B	1	1		
403B-26C	R: fxd, WW, 341. 9 ohms ±. 2% 1/2W	28480	403B-26C	1	1		
403B-26D	R: fxd, WW, 158. 1 ohms ±. 2%, 1/2W	28480	403B-26D	1	1		
403B-65A	Assy, printed circuit, includes, C7 thru C20 Q1 thru Q6, etc.	28480	403B-65A	1	1		
403B-65B	Assy, resistor board, includes, C21 R1 thru R4, etc.	28480	403B-65B	1	1		
403B-65C	Assy, resistor board, includes, C2 thru C5 R1 thru R4	28480	403B-65C	1	1		
403B-81A	Meter						
403B-901	Operating and Service Manual	28480	403B-901	1	2		
0130-0003	C: var, cer, 1. 5-7 pf ±10%, 500 vdcw	72982	503-000-COPO-10R	2	1		
0130-0017	C: var, cer, 8150 pf, 500 vdcw	72982	557-019-U2 P034R	1	1		
0140-0145	C: fxd, mica, 22pf ±5%, 500 vdcw	04062	DM15C220J	1	1		
0140-0151	C: fxd, mica, 820 pf ±2%, 300 vdcw	04062	DM15F821G	1	1		
0140-0178	C: fxd, mica, 560 pf ±2%, 300 vdcw	04062	DM15F561G	1	1		
0140-0218	C: fxd, mica, 160 pf ±2%, 300 vdcw	04062	DM15F161G	1	1		
0160-0205	C: fxd, mica, 10 pf ±5%, 500 vdcw	04062	DM15C100J	1	1		
0170-0033	C: fxd, 0. 18 µf ±10%, 600 vdcw	09134	Type 27	1	1		
0180-0008	C: fxd, elect., 4. 0 µf -15% +20% 60 vdcw	21520	PP4B60A2	1	1		
0180-0033	C: fxd, elect., 50 µf, 6 vdcw	56289	30D133A1	1	1		
0180-0039	C: fxd, elect., 100 µf, 12 vdcw	56289	30D154A1	1	1		
0180-0058	C: fxd, elect., 50 µf, -10% +100% 25 vdcw	56289	30D186A1	1	1		
0180-0059	C: fxd, elect., 10 µf,-10% +100%	56289	30D182A1	1	1		
0180-0060	C: fxd, elect., 200 µf -10% +100% 3 vdcw	56289	30D116A1	1	1		
0180-0063	C: fxd, elect., 500 µf -10% +100% 3 vdcw	56289	30D120A1	1	1		

#See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

℔ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
0180-0064	C: fxd, elect., 35μf -10% +100% 6 vdcw	56289	30D132A1	1	1		
0180-0104	C: fxd, elect., 200 μf, 15 vdcw	56289	30D174A1	1	1		
0180-0149	C: fxd, elect., 65 μf, 60 vdcw	56289	Type 30D	1	1		
0180-0150	C: fxd, elect., 1200 μf, 10 vdcw	56289	Type 34D	1	1		
0686-3015	R: fxd, comp, 300 ohms, ±5%,1/2W	01121	EB3015	1	1		
0687-1031	R: fxd, comp, 10K, 1/2W	01121	EB1031	3	1		
0687-1221	R: fxd, comp, 1.2K ±10%,1/2W	01121	EB1221	1	1		
0687-1531	R: fxd, comp, 15K, ±10%,1/2W	01121	EB1531	1	1		
0687-1541	R: fxd, comp, 150K ±10%,1/2W	01121	EB1541	1	1		
0687-2211	R: fxd, comp, 220 Ω ±10%,1/2W	01121	EB2211	1	1		
0687-2241	R: fxd, comp, 220K ±10%,1/2W	01121	EB2241	1	1		
0687-3331	R: fxd, comp, 33K ±10%,1/2W	01121	EB3331	2	1		
0687-3911	R: fxd, comp, 390 ohms ±10%,1/2W	01121	EB3911	1	1		
0687-3921	R: fxd, comp, 3.9K ±10%,1/2W	01121	EB3921	1	1		
0687-3951	R: fxd, comp, 3.9M ±10%,1/2W	01121	EB3951	1	1		
0687-4721	R: fxd, comp, 4.7K ±10%,1/2W	01121	EB4721	2	1		
0687-5621	R: fxd, comp, 5.6K ±10%,1/2W	01121	EB5621	2	1		
0687-6821	R: fxd, comp, 6.8K ±10%,1/2W	01121	EB6821	1	1		
0687-6831	R: fxd, comp, 68K ±10%,1/2W	01121	EB6831	1	1		
0693-1021	R: fxd, comp, 1K ±10%, 2W	01121	HB1021	1	1		
0727-0017	R: fxd, mfgl, 37.35 ohm ±1/2%, 1/2W	19701	DC1/2CR5	1	1		
0727-0050	R: fxd, mfgl, 180 ohms ±1%,1/2W	19701	DC1/2CR5	1	1		
0727-0056	R: fxd, mfgl, 216 ohms ±1/2%, 1/2W	19701	DC1/2AR5	1	1		
0727-0084	R: fxd, mfgl, 634 ohms ±1%, 1/2W	19701	DC1/2CR5	1	1		
0727-0096	R: fxd, mfgl, 920 ohms, ±1%,1/2W	19701	DC1/2CR5	1	1		
0727-0103	R: fxd, mfgl, 1.08K ±1%, 1/2W	19701	DC1/2CR5	1	1		
0727-0287	R: fxd, comp, 2 Meg ±1%, 1/2W	19701	DC1/2CR5	1	1		
0727-0443	R: fxd, comp, 19.1K ±1%, 1/2W	19701	DC1/2CR5	1	1		
0758-0007	R: fxd, mfgl, 150 ohms ±5%, 1/2W	07115	C20	1	1		
0758-0022	R: fxd, comp, 82K ±5%, 1/2W	07115	C20	1	1		
0758-0048	R: fxd, mfgl, 8.2K ±2%, 1/2W	07115	C20	1	1		
0758-0051	R: fxd, comp, 43K ±5%, 1/2W	07115	C20	1	1		
0758-0073	R: fxd, mfgl, 24K ±2%, 1/2W	07115	C20	1	1		
0758-0074	R: fxd, mfgl, 27K ±2%, 1/2W	07115	C20	1	1		
0758-0076	R: fxd, mfgl, 68K ±2%, 1/2W	07115	C20	1	1		
1400-0011	Fuse, 1/16 Amp	75915	125002	1	1		
1420-0015	Battery, Nickel Cadmium	88220	6.0V/255B	4	4		
1450-0048	Indicator, Neon	08717	858R	1	1		
1850-0060	Transistor, PNP	02735	3748	1	1		
1850-0064	Transistor, PNP	02735	2N1183	1	1		
1850-0096	Transistor, PNP	01295	2N2189	3	3		
1854-0017	Transistor, NPN	03508	2N706A	2	2		
1901-0025	Diode, Silicon, 50 ma, 100 piv	07910	CD1598	5	5		
1901-0027	Diode, Silicon	73293	HD5004	2	2		

#See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
2100-0144	R: var, comp, 250K ±30% .2W	11237	UPE70	1	1		
2100-0154	R: var, comp, 1K ±30%, 3/10W	11237	UPE70	1	1		
2100-0240	R: var, WW, 50 ohms ±20%, 1W	11236	Series 110	1	1		
2100-0390	R: var, comp, duel, 2K and 6K	71590	Series 5 Type 73-2	1	1		
2100-0391	R: var, WW, 1K ±20% 1.25W	11236	Series 110	1	1		
3101-0033	Switch - Slide: DPDT 115-230V	42190	4633	1	1		
7123-0101	Washer, fluorescent indicator for use with Function Switch Knob	91345	-----	1	1		
8120-0078	Cord, Power	70903	KH4147	1	1		
9100-0172	Transformer	98734	6-2249	1	1		

#See introduction to this section

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

CODE NO.	MANUFACTURER	ADDRESS
00334	Humidial Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.
00853	Sangamo Electric Company, Ordill Division (Capacitors)	Marion, Ill.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	Pacific Semiconductors, Inc.	Culver City, Calif.
01295	Texas Instruments, Inc. Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01930	Amerock Corp.	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.	Morristown, N.J.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04298	Elgin National Watch Co., Electronics Division	Burbank, Calif.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Prods., Inc. Electronic Tube Div.	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc. Western Division	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04796	Sequoia Wire & Cable Company	Redwood City, Calif.
04870	P. M. Motor Co.	Chicago 44, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.
05624	Barber Colman Co.	Rockford, Ill.
05729	Metropolitan Telecommunications Corp., Metro Cap. Div.	Brooklyn, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
06004	The Bassick Co.	Bridgeport, Conn.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07966	Shockley Semi-Conductor Laboratories	Palo Alto, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada
08717	Sloan Company	Burbank, Calif.
08718	Cannon Electric Co. Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S. Inc.	Lowell, Mass.
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays, Inc.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11312	Microwave Electronics Corp.	Palo Alto, Calif.
11534	Duncan Electronics, Inc.	Santa Ana, Calif.
11711	General Instrument Corporation Semiconductor Division	Newark, N.J.
11717	Imperial Electronics, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12697	Clarostat Mfg. Co.	Dover, N.H.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
15909	The Daven Co.	Livingston, N.J.
16688	De Jur-Amsco Corporation	Long Island City 1, N.Y.
16758	Delco Radio Div. of G. M. Corp.	Kokomo, Ind.
18873	E. I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G.E., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
37942	P. R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C. A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Company	Lexington, Mass.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Swissvale, Pa.
62119	Universal Electric Co.	Owosso, Mich.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
66346	Wollensak Optical Co.	Rochester, N.Y.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	New York, N.Y.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio Inc.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp.	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71450	CTS Corp.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C. P. Clare & Co.	Chicago, Ill.
71528	Standard-Thomson Corp., Clifford Mfg. Co. Div.	Waltham, Mass.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A. O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	Hamden, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73734	Federal Screw Products Co.	Chicago, Ill.

00015-25
Revised: 25 May 1962

From: F.S.C. Handbook Supplements
H4-1 Dated: April 1962
H4-2 Dated: March 1962

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

CODE NO.	MANUFACTURER	ADDRESS
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74455	J. H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E. F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littelfuse Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C. W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J. W. Miller Co.	Los Angeles, Calif.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	Bendix Pacific Division of Bendix Corp.	No. Hollywood, Calif.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	Potter and Brumfield, Div. of American Machine and Foundry	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78283	Signal Indicator Corp.	New York, N.Y.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	Pasadena, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80120	Schnitzer Alloy Products	Elizabeth, N.J.
80130	Times Facsimile Corp.	New York, N.Y.
80131	Electronic Industries Association Any brand tube meeting EIA standards	Washington, D.C.
80207	Unimax Switch, Div. of W. L. Maxson Corp.	Wallingford, Conn.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Laboratories, Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Fulton Controls Co.	Columbus 16, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81312	Winchester Electronics Co., Inc.	Norwalk, Conn.
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Components Div., Industr. Tube Operations	Newton, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Allen B. DuMont Labs., Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc., Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls, Inc., Div. of Texas Instruments, Inc., Spencer Prods.	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Manufacturing Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83053	Western Washer Mfr. Co.	Los Angeles, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	Pyramid Electric Co.	Darlington, S.C.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Union, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics, Inc.	New York, N.Y.
84396	A. J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85474	R. M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86197	Clifton Precision Products	Clifton Heights, Pa.
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87216	Philco Corp. (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
89636	Carter Parts Div. of Economy Baler Co.	Chicago, Ill.
89665	United Transformer Co.	Chicago, Ill.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91345	Miller Dial & Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers,'Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91921	Minneapolis-Honeywell Regulator Co., Micro-Switch Division	Freeport, Ill.
92196	Universal Metal Products, Inc.	Bassett Puente, Calif.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94144	Raytheon Mfg. Co., Industrial Components Div., Receiving Tube Operation	Quincy, Mass.
94145	Raytheon Mfg. Co., Semiconductor Div., California Street Plant	Newton, Mass.
94148	Scientific Radio Products, Inc.	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	East Paterson, N.J.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95264	Lerco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95354	Methode Mfg. Co.	Chicago, Ill.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96256	Thordarson-Meissner Div. of Maguire Industries, Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98734	Palo Alto Engineering Co., Inc.	Palo Alto, Calif.
98821	North Hills Electric Co.	Mineola, N.Y.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Ill.
99957	Technology Instrument Corp. of Calif.	Newbury Park, Calif.

THE FOLLOWING H-P VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

CODE NO.	MANUFACTURER	ADDRESS
0000F	Malco Tool and Die	Los Angeles, Calif.
0000I	Telefunken (c/o American Elite)	New York, N.Y.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000N	Nahm-Bros. Spring Co.	San Leandro, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
0000T	Texas Instruments, Inc. Metals and Controls Div.	Versailles, Ky.
0000U	Tower Mfg. Corp.	Providence, R.I.
0000W	Webster Electronics Co. Inc.	New York, N.Y.
0000X	Spruce Pine Mica Co.	Spruce Pine, N.C.
0000Y	Midland Mfg. Co. Inc.	Kansas City, Kans.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AA	British Radio Electronics Ltd.	Washington, D.C.
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000CC	Computer Diode Corp.	Lodi, N.J.
000EE	A. Williams Manufacturing Co.	San Jose, Calif.
000FF	Carmichael Corrugated Specialties	Richmond, Calif.
000GG	Goshen Die Cutting Service	Goshen, Ind.
000HH	Rubbercraft Corp.	Torrance, Calif.
000II	Birtcher Corporation, Industrial Division	Monterey Park, Calif.
000KK	Amatom	New Rochelle, N.Y.
000LL	Avery Label	Monrovia, Calif.
000MM	Rubber Eng. & Development	Hayward, Calif.
000NN	A "N" D Manufacturing Co.	San Jose 27, Calif.
000PP	Atohm Electronics,	Sun Valley, Calif.
000QQ	Cooltron	Oakland, Calif.

00015-25
Revised: 25 May 1962

From: F.S.C. Handbook Supplements
H4-1 Dated: April 1962
H4-2 Dated: March 1962

WARRANTY

All our products are warranted against defects in materials and workmanship for one year from the date of shipment. Our obligation is limited to repairing or replacing products (except tubes) which prove to be defective during the warranty period. We are not liable for consequential damages.

For assistance of any kind, including help with instruments under warranty, contact your authorized hp Sales Representative for instructions. Give full details of the difficulty and include the instrument model and serial numbers. Service data or shipping instructions will be promptly sent to you. There will be no charge for repair of instruments under warranty, *except transportation charges.* Estimates of charges for non-warranty or other service work will always be supplied, if requested, before work begins.

CLAIM FOR DAMAGE IN SHIPMENT

Your instrument should be inspected and tested as soon as it is received. The instrument is insured for safe delivery. If the instrument is damaged in any way or fails to operate properly, file a claim with the carrier or, if insured separately, with the insurance company.

SHIPPING

On receipt of shipping instructions, forward the instrument prepaid to the destination indicated. You may use the original shipping carton or any strong container. Wrap the instrument in heavy paper or a plastic bag and surround it with three or four inches of shock-absorbing material to cushion it firmly and prevent movement inside the container.

GENERAL

Your authorized hp Sales Representative is ready to assist you in any situation, and you are always welcome to get directly in touch with Hewlett-Packard service departments:

CUSTOMER SERVICE

Hewlett-Packard Company
395 Page Mill Road
Palo Alto, California, U.S.A.
Telephone: (415) 326-1755
TWX No. PAL AL 117-U
Cable: "HEWPACK"

OR (In Western Europe)

Hewlett-Packard S.A.
54-54bis Route Des Acacias
Geneva, Switzerland
Telephone: (022) 42. 81. 50
Cable: "HEWPACKSA"

PRINTED IN U.S.A.